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EDITORIALS AND ANNOTATIONS

OSTEOCHONDRITIS JUVENILIS

It may be recalled that Perthes gave the name osteochondritis deformans juvenilis to a disease of the hip that presented a remarkable cycle of radiographic changes ending in resolution and that he wished to distinguish from arthritis deformans juvenilis. The term was one of convenience, not a descriptive name based on any knowledge of pathology.

Osteochondritis juvenilis was soon used as a convenient label for any perplexing appearance in a centre of ossification anywhere in the body. Unfamiliarity with the varied manifestations of normal ossification led to this diagnosis when there were in fact no radiological abnormalities at all, and sometimes not even symptoms. For instance pain in a child's heel would be associated with multiple dense apophysial centres, normal enough here but suggesting the stage of " fragmentation " in Perthes' disease: the label of osteochondritis juvenilis would be confidently attached. Identical radiological appearances of the opposite and unoffending heel were no deterrent: " symptomless osteochondritis juvenilis " was the naïve explanation.

It is not surprising that many hypotheses were built up, mainly from radiological speculation and often based on the pathological misconceptions of Leriche and Policard. For instance, the affection of the tibial tubercle in " les jeunes gens sportifs qui font beaucoup de football " known as Osgood-Schlatter disease soon attracted a like mythology, although the radiographs are usually normal unless, as sometimes happens, a small flake and corresponding hollow betray avulsion.

Speculation has been encouraged because opportunities for bona fide exploration have been rare, and because the principal pathological changes have been complicated by the secondary effects of the body's reactions and mechanical stresses. The principal change found in the hip has been a large focus of subchondral necrosis and destruction. The same change is seen in the dorso-distal part of the metatarsal head in Freiberg's disease and beneath the radial articular surface of the lunate [semilunar] bone in at least some cases of Kienböck's disease. The overlying articular cartilage, though thickened, undergoes subsidence into a yielding crater and can be pressed in and out by the application and release of pressure. There is thus a fundamental resemblance to osteochondritis juvenilis of the hip and at least a superficial resemblance to osteochondritis dissecans as exemplified in the elbow and the knee (so-called König's disease). Whether osteochondritis juvenilis and osteochondritis

dissecans are basically identical remains uncertain. For instance, is osteochondritis juvenilis of the capitulum (Panner's disease) osteochondritis dissecans writ large? O'Garra touches on the point in this number in his paper on "The Radiographic Changes in Perthes' Disease." Insisting on the importance of lateral radiography, he groups his cases into those with affection of the whole epiphysis and those with affection of the anterior part only.

Since Fairbank's (1933) classic paper, it has been generally believed that osteochondritis dissecans represents fracture or its effects. In the early stages of Perthes' disease, before there is much collapse, we have seen subchondral fissures. In Kienböck's disease we have found histological evidence of fractures, but it has been impossible to say whether they were primary or secondary. In Freiberg's disease the idea of an infraction, abandoned by its author, has been revived by Smillie (1957) as a fatigue fracture; confirmation of this observation would perhaps help to explain the dorsal chondro-osseous outgrowth that antedates the depression in the head. Braddock (1959) has recently described experiments that suggest a relative fragility of the metatarsal epiphysis in adolescent girls, those most subject to the disease.

If we admit a kinship between Perthes' disease, Freiberg's disease and Kienböck's disease, and use the name osteochondritis juvenilis for them, whether or not they are first cousins of osteochondritis dissecans—and, if we exclude such intruders as strains of tendon insertions and the epiphysial dysplasias and dystrophies—there remain a very few instances of a clinical and radiological evolution that has seemed so specific as to deserve tentative acknowledgment even though scientific proof of paternity is wanting. We have in mind Köhler's (first) disease of the navicular [tarsal scaphoid] bone, Panner's disease of the capitulum and Calvé's disease of the vertebra. Since Compere, Johnson and Coventry (1954) pointed out that Calvé's disease might be a manifestation of eosinophilic granuloma, there has been a tendency to regard this as the only cause, in spite of the wise caution of Compere himself, rightly quoted by Weston and Goodson in their paper on Calvé's disease in this number. They have added to our knowledge the observation that the vertebral body can collapse into a flattened disc within the brief space of fifteen days, in sharp contrast with the long duration of reconstruction so well exemplified in the four cases followed for very many years that were recently described by Fripp (1958).

In closing this note on the most eponymous of affections, we may recall that, although it is common knowledge that Legg and Calvé anticipated Perthes by a short head, it is less well known that James Paget (1870, 1891) anticipated König, Osgood and Schlatter by very many years.

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ACCIDENT SERVICES IN GREAT BRITAIN

There is everywhere a growing dissatisfaction with the state of the services available for the treatment of injured people. Indeed the prevention of accidents and the treatment of the injured is one of the gravest medico-social problems. In young people accidents are the biggest cause of death—far greater than the peril of disease. The economic loss to the community is enormous.

The need for improvements has been stated repeatedly, and members of the British Orthopaedic Association have taken part in several commissions of inquiry. The Association itself published a memorandum in 1943 urging the development of comprehensive accident services. In spite of accident prevention campaigns the accident rate rises, and although increased facilities have been made available by the National Health Service the organisation of accident services remains inadequate.

The British Orthopaedic Association has again given serious attention to the problems raised. A sub-committee of its Executive body has spent much time in its consideration, and a report was submitted to the full Association at its meeting in Torquay on April 30, 1959. In its final form this report has now been published by the Executive Committee and is printed in this number of the Journal.

Naturally the conditions referred to in this report are those with which we are familiar in Great Britain and Northern Ireland; nevertheless we believe that similar conditions are to be found in most other parts of the world, and it is for this reason in particular that we feel we should include it here.

As will be seen, emphasis is given to organisation, staffing, accommodation and surgical training. Generally, difficulties arise from having too many rather than too few hospitals in which injured people are sent for treatment. Many of these hospitals are too small and too poorly equipped to maintain a twenty-four-hour service. There should be a concentrated service in designated general hospitals with proper staff and equipment to provide such a service with every necessary specialist service available at any hour of the day and night. General practitioners of medicine should be encouraged to take part in the service as members of the team. Buildings should be designed for the purpose of receiving and treating injured people, so that no unnecessary delay in treatment should occur. These services should be organised nationally in areas the size of which should vary with the need, depending upon the population at risk. Minor injuries cannot be dismissed as being suitable for treatment in any other kind of hospital unit. Nevertheless if small peripheral units were integrated with the main accident service they would have an important function. In rehabilitation the result will depend upon the standard of initial treatment which is the most important single stage. Teaching in accident surgery requires much greater attention in the curriculum of medical schools.

There is need for further research into the reaction of tissues to injury and into the processes of repair. Some of the most valuable research along these lines has been done at centres where comprehensive accident services exist, and this is a strong argument in favour of their further development and for improved facilities for research. The complete nation-wide organisation will take time and will be costly; yet it is urgent that a further effort be made concurrently with an intensification of preventive measures.

The memorandum now published is issued under the authority of the Executive Committee of the British Orthopaedic Association, all the members of which have had a hand in its writing. Particular acknowledgment should, however, be paid to Sir Reginald Watson-Jones, Professor Bryan McFarland and Mr H. J. Seddon for their stimulus, to Mr J. C. Scott for his driving energy, and to Mr J. Crawford Adams for his extreme patience in the completion of the document.

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BRITISH ORTHOPAEDIC ASSOCIATION

MEMORANDUM ON ACCIDENT SERVICES 1959

Injury kills or disables the most active and productive members of the community; for them the risk of accident has become much greater than the peril of disease. It accounts for more than 80 per cent of the deaths of persons under the age of eighteen years. In Great Britain, on average, forty-five men or women die from injury every day of the year—five from accidents at work, sixteen during travel and twenty-four from injuries in their homes. Injuries sustained while in travel cost the community £172 million in 1955, and the cost is rising. Injuries at work cause more loss of time and productivity than industrial disputes.

The prevention of accidents and the treatment of the injured are one of the greatest of our medico-social problems. At a time when this country has applied itself earnestly to social problems and to the conquest of disease, it has failed to take proper action to reduce disablement from injury. Despite the increased facilities made available by the National Health Service the organisation of fracture and accident services has remained inadequate, and becomes increasingly so as the incidence of accidents rises.

The British Orthopaedic Association supported the recommendations of the British Medical Association in its report on the treatment of fractures published in 1935[1], and contributed to the report of a Government Interdepartmental Committee on Persons Injured in Accidents in 1939[2]. Whereas previously the treatment of fractures had been so haphazard that the results were often disastrous, it was laid down firmly that there should be proper organisation with unity of control and continuity of treatment throughout under the direction of surgeons whose special concern it was to treat fractures. A great impetus was thereby gained. Until then permanent disability and some incapacity for work had been accepted complacently in about 70 per cent of all fractures. Where these recommendations were adopted it was soon reduced to a small proportion and disability periods were reduced from years to months. There the advance was very great indeed.

The British Orthopaedic Association then published its Memorandum on Accident Services in 1943[3], endeavouring to achieve the same organisation with unity of control and continuity of treatment for all injuries, in all parts of the body. Again advances were made and a number of accident services were established. It was thought that the evidence produced was so sure that the need for completely organised accident services with full staff, proper equipment and sufficiency of beds need be urged no longer. But this proves not to have been so.

At the present time the organisation for the treatment of those injured in accidents remains gravely deficient. In the last ten years, as in every other field of surgery, there has been remarkable progress in the technique of the treatment of injuries; but these advances, although available to the victims of injury in a few special centres, have not been applied generally. The establishment of fracture and accident services has been so deficient as to perpetuate in the greater part of the country the conditions that provoked such strong criticism by the British Medical Association in 1935, the Interdepartmental Committee in 1939 and the British Orthopaedic Association in 1943.

Awareness and criticism of the present disorganised state of the hospital service so far as the treatment of injured patients is concerned were evident at the meeting of the British Medical Association in Birmingham in 1958[4], and the faults of local organisation were stressed. But it is idle to lay the blame for present shortcomings on those on the spot: something more is required in addition to individual effort.

The British Orthopaedic Association is convinced that the accident services of Great Britain are seriously inadequate by reason of four things: failures of organisation, failures of staffing, failures of accommodation and failures of surgical training.

Failures of organisation—A fundamental defect of the present system is the diffusion of injured patients among hundreds of hospitals. In the common endeavour to provide not only emergency treatment but also continuity of treatment the general standard of care is bound to be low. *How can it be otherwise if every hospital, small or large, equipped or not equipped, properly staffed or not properly staffed, attempts to deal with every accident problem, not only for first-aid but for the whole treatment?*

In the London area the situation is especially bad: there are more than one hundred casualty receiving hospitals, few of which receive enough accident cases to warrant an efficient twenty-four-hour service; nor are they fully equipped or properly staffed. In many of these hospitals the casualty officer leaves at 5 o'clock in the evening, and his work thereafter is delegated to a junior house officer who has other duties. In most of them radiographers have at that time finished their duties and are only " on call." In most of them there is no theatre immediately available for accident surgery. Yet a comprehensive accident service demands the immediate attention of orthopaedic and other specialist surgeons, anaesthetist, clinical pathologist, radiographer and theatre staff—all easily available at any hour of the day and night. Clearly this full service cannot be expected in every one of several hundred casualty receiving hospitals. There should be a *limited number* of hospitals in which a full service is provided and to which so far as possible all injured patients are sent.

In some provincial cities comprehensive accident services which fulfil these requirements have been developed[5]. Nevertheless the general position is that casualties are diffused too widely among too many small hospitals, few of which are suitably equipped or adequately staffed to deal properly with accidents. There should be regional organisation on a national scale by which injured patients are sent to the hospital centre that is equipped to receive and treat them. No hospital should give more than first-aid treatment if it is not equipped and staffed to do more than this. It is not in the best interests of a severely injured patient that he be conveyed to the nearest hospital if that hospital is not equipped and staffed to deal properly with his injuries. It is usually far better for him to be taken the extra distance to a hospital that is prepared for this special work, even though the ambulance may pass other hospitals on the way. *Serious delay in the treatment of the injured occurs, not in transit to hospital, but within the hospital that receives the casualties—through poor organisation and inadequate facilities.*[6]

Hospitals other than those with accident units* should be divided into two categories. There should be some that would receive casualties, treat the minor ones and refer serious cases of injury to the nearest accident unit; and others—this would apply particularly in large cities where several small hospitals happen to be close together—would not receive accident cases of any kind. The accident service would therefore consist of a close-knit organisation, with a central accident unit and a number of satellite hospitals.[7]

Failures of staffing—At present there are not enough surgeons with orthopaedic training to deal personally with every locomotor injury. Nevertheless if injured patients were segregated in organised accident units at selected hospitals, as is proposed in this memorandum, the available talent would be put to much better use.

There is urgent need for an increase in number and an improvement in quality of junior medical staff. Yet this problem might well solve itself if good accident services were established; keen young men would be attracted to them.

* In the remainder of this memorandum the term *accident unit* will be used to denote the central part of the organisation, the term *accident service* to embrace the central unit and the peripheral hospitals associated with it.

At peripheral hospitals there is need for surgeons, with training appropriate to their responsibilities, who are skilled in the diagnosis of the severity and extent of injuries, in resuscitation, and in the treatment of minor injuries. Both in the accident unit and in the peripheral hospital there is an important place for the general practitioner, similarly trained.

There are deficiencies of ancillary staff, both numerically and qualitatively: unless it is well organised nurses and radiographers are not attracted to this vitally important but exacting field of work. The efficiency of junior medical and ancillary staff is determined largely by the enthusiasm and ready availability of the consultants in charge of accident work. The regrettable tendency to leave the inexperienced to bear responsibility for the care of the injured will have to cease.

Failures of hospital accommodation—In most hospitals the number of beds allocated for patients with injuries is unrealistic. They can often be admitted only at the expense of those awaiting admission whose treatment is less urgent—though often no less important—and this is a major cause of the inflation of waiting lists, especially in orthopaedics and to some extent in general surgery. But it is not in the allocation of accident beds alone that hospital accommodation is deficient. The buildings themselves are inadequate for present needs and cannot be made adequate by mere patching up. In no branch of the hospital service does a comment of Sir Harry Platt apply more aptly than to the accommodation provided for the reception and treatment of injured patients: "We have been compelled to contemplate another long period of practising twentieth-century medicine in nineteenth-century structures."

Failures of Surgical Training—Many young men enter the hospital service and general practice poorly equipped by training and experience to assume the responsibilities expected of them. In accident work they find themselves in positions of legal vulnerability, which itself is a discouragement to recruitment. Where accident services have been established in teaching hospitals the training of medical students has been simplified and improved. If in the new accident services the organisation, staffing and accommodation are brought to a high pitch of efficiency, sound postgraduate teaching and fitness to assume responsibility will also be assured.

RECOMMENDATIONS

The British Orthopaedic Association urges Her Majesty's Government to take steps to implement the following recommendations.

A. GENERAL

1. Accident services should be organised on a nation-wide scale to provide adequate accommodation, equipment and staff for the treatment of all varieties of injury, under the best conditions, at any time of the day or night.

2. The country should be divided into areas, each with its comprehensive accident unit based upon an existing general hospital. This division should apply to large cities as well as to country districts, and in general—having regard to population and distance—the size of each area should be such that a twenty-four-hour service can be maintained economically at the hospital selected for the purpose. Often the accident unit could be sited in relation to main trunk roads and industrial concentrations. In some areas, particularly where there are a number of small towns, first-aid units should be established in peripheral hospitals. They should all form part of the accident service with its headquarters at the general hospital designated for this purpose.

3. At hospitals designated as accident centres the staff structure should be overhauled, to ensure full supervision by experienced orthopaedic sugeons, to provide more adequate staff of intermediate grade than is at present available, and to enrol interested general practitioners.

4. Hospitals not designated as accident centres should be discouraged from receiving injured patients. Patients arriving there under special circumstances should be treated if the injury is a minor one, but all patients with serious injuries should be transferred to the appropriate accident unit as soon as possible.

5. The ambulance services should be adjusted to meet these provisions.

The Association believes that only by the adoption of such measures as these can there be a radical improvement in the day-to-day service to the community so far as accidents are concerned. Only thus can there be any assurance that those who are injured—whether slightly or severely—will receive the best available treatment at the hands of those best qualified to give it. Moreover, a structure of accident services on the lines suggested would be better able to meet the emergencies created by major disasters such as rail or air crashes: *for the quality of the medical care available to the victims of such disasters will depend upon the standards that already exist in the community.*

B. THE STRUCTURE AND ORGANISATION OF AN ACCIDENT SERVICE

6. *The accident unit*—This should be a department of a general hospital, or, in rare circumstances, in a special centre related to a general hospital. The accommodation, for both out-patients and in-patients, should be in one block with its own entrance for ambulances. It should contain all the facilities needed for reception and immediate treatment, including its own x-ray unit, operation theatre or theatres and the necessary ancillary services.

7. The accident unit should be responsible for the *reception* of all injured patients.

8. It should have immediately available every facility for the *resuscitation* of the severely injured.

9. It should provide for the *continued treatment* of all patients with injuries of the locomotor system and of patients with multiple injuries. The continued treatment of patients with other types of injury—such as those of the head, chest, abdomen or eyes—should become the responsibility of the appropriate specialist department of the hospital.

10. The accident unit should be closely linked with regional centres for the treatment of special surgical conditions—head injuries, facio-maxillary injuries, orthopaedic disorders and burns—where such centres do not exist in the same hospital.

11. *Accommodation and staff*—There would necessarily be considerable variations according to the nature of the area served. The size of each unit should be such that it is economical to maintain a full twenty-four-hour service with all its ancillary services. The average requirement is between 150 and 250 accident beds per half-million of the population, assuming that beds for convalescence are also available, especially for the elderly.

12. Since injuries of the locomotor system account for three-quarters of all injuries it is clear that the main responsibility must fall upon orthopaedic surgeons, one of whom should be in administrative charge of the accident service. But those in other specialities are needed to share the burden. The orthopaedic surgeon should confine his responsibility for treatment to injuries of the limbs and spine; the neurosurgeon will deal with injuries of the head, the thoracic surgeon with injuries of the chest, the abdominal surgeon with visceral injuries, the plastic surgeon with burns, and so on. The closer the collaboration between these various consultants the better. Here it must be emphasised that it is unrealistic to attempt to train surgeons to be expert in every field of surgery—locomotor, abdominal, urogenital, cardiac, thoracic, cerebral—or in injuries of every part. The creation of " casualty surgeons " who accept full responsibility for the treatment of injuries in every part of the body would therefore be an undesirable development.

13. Upon the character of the junior staffing new thought is required. It will not be possible to rely entirely on the short-term employment of young men in training for consultant appointments, although these men will continue to fulfil an important function. General practitioners who have a special interest in this kind of work could carry considerable responsibility if their services were properly organised. With general practitioners and junior surgical staff the dominant requirement is integration in a proper team, with unremitting supervision by the consultants and with full facilities for consultation and the exchange of ideas.

14. *Peripheral hospitals*—However efficiently an accident unit may work it cannot of itself provide a solution to the whole problem of accidents. Accidents are unpredictable and urgent and above all ubiquitous. The peripheral hospitals have a vital role, and as much thought should be given to their equipment and staffing as is required for the accident unit. The central unit and the peripheral hospitals together form the accident service.

15. There should be available at all times of day and night—a rota would be necessary—a clinician who is experienced in two respects. He must be able to distinguish between the minor injury and the injury that is actually or potentially serious. In the latter case the patient will be sent on to the accident unit when fit to travel: an apparently minor injury, such as a cut in the hand that may involve a tendon sheath, must be recognised and the patient sent, as a matter of urgency, to the accident unit. This clinician must also be competent to deal efficiently with minor injuries—the small superficial burn, the Colles's fracture, the sprained ankle. A surgeon resident in a small town, or a general practitioner, is the right man for this work, provided that his training in accident surgery is adequate. He is as much a part of the accident service as a man in the central unit, and it is the duty of the surgeon in charge of the service to ensure an effective liaison between the unit and its peripheral hospitals and their staffs.

16. *Casualty departments*—Emergency receiving rooms for other than accident cases will still be needed in designated hospitals, but casualty departments as they used to be known should exist no longer.

17. *Rehabilitation*—Continuity of supervision up to the stage of full or greatest possible recovery and until the time of occupational resettlement is essential, and full provision for rehabilitation should be made. It is cardinal, however, that the clinical and functional result depends on the standard of primary treatment, which is thus the most important single step in rehabilitation.

18. *Teaching in accident surgery*—It is recommended that the academic boards of medical schools should give greater attention to this aspect of medicine. It has already been indicated that where comprehensive accident services have been established the teaching of medical students has been greatly simplified and improved. The hospitals designated for complete fracture and accident units would almost invariably include every teaching hospital. Even if in these teaching hospitals the allocation of beds to accident cases were necessarily limited by other teaching requirements, there could still be planned an association with another hospital to which injured patients were transferred within a few days of their primary treatment, still under the same control, and still available for the teaching of undergraduate and postgraduate students.

19. The British Orthopaedic Association supports, and recommends the support of, the Royal Colleges of Surgeons in their insistence on training in accident surgery before candidates sit for the Fellowship examinations. Good training and the provision of efficiently organised services will go far to encourage the recruitment of the younger men to work in accident departments: not only does this apply to surgeons, but also to ancillary staff, many of whom avoid this work because of the discouragements that are at present found.

Postgraduate courses, which should include practical instruction, should be available to general practitioners, who should be encouraged to attend them. Here the interest of the College of General Practitioners might well be sought.

20. *Research*—There is still much to be learned of the reaction of tissues to injury. There has been much encouraging research on the problems of wound healing, the time of union of fractures, the delaying influences in repair, the regeneration of nerves, the union of ruptured and severed tendons, the growth of skin, the transplantation of tissues, and the techniques by which these healing processes may be accelerated or delayed. Almost without exception this research has been carried out at centres where accident services exist, and this is a further argument in favour of their establishment throughout this country.

CONCLUSION

The organisation of accident services must be undertaken by the state as a quasi-military operation.

To provide the whole country with integrated accident services on the lines suggested in this memorandum will clearly mean the expenditure of considerable sums of money over many years. Nevertheless, a beginning must be made; and the British Orthopaedic Association recommends that Her Majesty's Government should authorise each Regional Hospital Board, in conjunction with Boards of Governors of Teaching Hospitals, to set up forthwith at least one comprehensive accident service within its area. In the fullness of time such units would be multiplied and integrated to form a nation-wide accident service. If the Government so desired, the Association would be willing to nominate an Advisory Panel to assist in the organisation of such an accident service.

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THE RADIOGRAPHIC CHANGES IN PERTHES' DISEASE

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Considering the attention that is given to disorders of the hip and considering also how long the condition now generally known as Perthes' disease has been recognised, it is surprising that its pathogenesis is still uncertain. It is true that there is some similarity to changes in the upper femoral epiphysis that may arise when there is a specific and identifiable lesion of the neck of the femur, and in the course of general disorders such as cretinism, Mongolism, reticuloses, sickle-cell anaemia, dysplasia epiphysialis multiplex and osteo-chondro-dystrophy. But in classical Perthes' disease no causative factor can be defined. The observations in this series are not new, but are recorded in the hope that they will stimulate interest which may possibly lead to a better understanding of the condition. It is fairly common, and the small number of patients now presented (rather less than half of those treated at the Royal Liverpool Children's Hospital in the period reviewed) were selected because the radiographic examinations were comprehensive and the appearances distinct (Table I).

It seems that the changes in the radio-opaque material of the femoral head may involve the whole epiphysis or mainly the anterior part only (Figs. 1 and 2). In the present series twenty cases fell into the latter, and five into the former group. It might be that this difference forms the basis for Legg's " cap " and " mushroom " types with their differing prognosis, and for the two types described some thirty years later by Fèvre as " central " and " marginal."

Group 1: " Anterior " Perthes' disease—In these patients the anterior half or two-thirds of the head of the femur is affected. A change may occur very early and can be seen in the lateral radiograph before it is detectable in the antero-posterior view (Fig. 3). Commonly the anterior segment of the head is at first abnormally dense, and this area may be clearly demarcated from the normal posterior segment (Figs. 4, 6 and 13). Soon the dense bone begins to disappear and is replaced by a translucent area initially shaped like a tongue. This spreads through the whole front of the epiphysis, leaving a peripheral rim of bone (Figs. 4, 10 and 14). Coincidently a metaphysial change, if visible, lies at this stage mainly in the anterior third of the neck of the femur (Fig. 9). This was never seen later than six months after the onset, though the necrosis of the overlying epiphysis persisted much longer. The process of apparent fragmentation and reconstruction was completed rapidly in children under eight years of age (Figs. 6 to 8), but seemed to be much slower in older children. Figure 12 is representative of the latter; one child was aged nine and the other eleven years.

Generally, reconstruction was first shown as a fine strip of new bone in the periphery of the front of the head (Figs. 5, 15 and 18), and this spread slowly forwards and inwards until the apparent defect was made good (Figs. 11, 15 and 16). It was noted that in the young child apparent flattening in the early stages, however marked it might be, did not prevent the ultimate reconstruction of a well shaped head provided treatment was prompt and adequate (Case 3; Figs. 17 to 19).

Group 2: Involvement of the whole epiphysis—Five patients were so affected and, in all, flattening and apparent fragmentation occurred early. In one patient there was also a lesion in the centre of the metaphysis (Fig. 20). Reconstruction did not appear to begin as early as in the first group; as much as a year might elapse before any change was seen, and then it took the form of a slow progressive increase in the depth of the epiphysis (Figs. 21 and 22).

TREATMENT AND RESULTS

The children in this series were treated by traction in recumbency with the exception of a boy of twelve, who walked about in a weight-relieving caliper and a patten on the other leg. The period of recumbency was seventeen to twenty-seven months. Between two and a half to three years after the onset all the children except two were free from pain, had no limp,

TABLE I

DETAILS OF TWENTY-FIVE PATIENTS

ANTERIOR PERTHES' DISEASE					WHOLE HEAD PERTHES' DISEASE			
Case number	Age at onset (*years*)	Sex	Epiphysial index*	Notes	Case number	Age at onset (*years*)	Sex	Epiphysial index*
1	4	M	46–46	Bilateral	21	2½	F	33
2	5	F	43	—	22	4	M	36
3	5	M	36	—	23	4	M	25
4	5	M	34	—	24	5	M	32
5	5	M	37	—	25	6	M	25
6	5	M	37–40	Bilateral				
7	5	M	39	—				
8	5	M	37	—				
9	5	M	37	—				
10	5	M	26	—				
11	6	F	34	—				
12	6	F	30	—				
13	6	M	34	—				
14	6	M	25	—				
15	6	M	33	—				
16	7	M	30	—				
17	7	M	28	—				
18	7	F	40	—				
19	9	M	25	Gross limitation of movement				
20	11	M	26	Rotation limited				

The normal values for the epiphysial index are: under 7 years of age, 45–55; over 7 years of age, 35–45

* At review

and had full mobility of the hips. The two exceptions were boys of nine and twelve. At the time of diagnosis the necrosis in both of them was anterior. One had severe limitation of abduction and rotation and an obvious limp (Case 19; Fig. 12). The other was healed three and a half years after the onset; rotation was limited and the head was severely flattened, especially anteriorly (Case 20).

In the group with " anterior " disease, eighteen patients were under eight years of age at the time of diagnosis. The radiographic results show that in eleven of these the epiphysial index (Eyre-Brook 1936) was within the normal range, and in only three did the index fall below 30. In comparison, of the five patients in whom the whole femoral head had suffered,

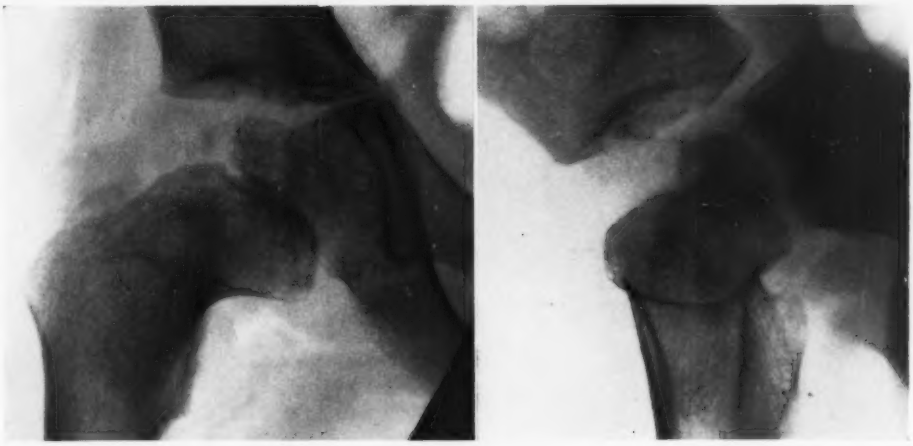

FIG. 1

Anterior Perthes' disease fourteen months after the onset. The appearance is that of a clean-cut removal of the anterior half of the femoral head, leaving a normal posterior half.

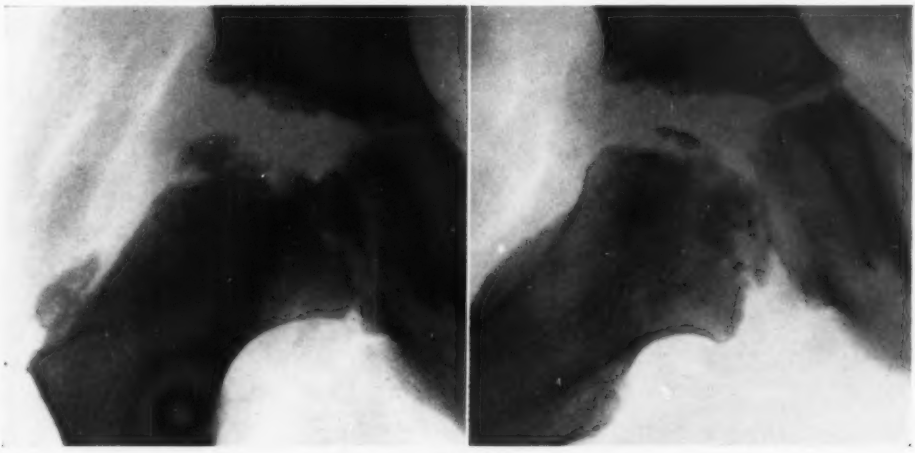

FIG. 2

Perthes' disease of the whole femoral head nine months after the first symptom. The entire epiphysis appears to be fragmented and flattened.

the epiphysial index was decidedly below normal in two, rather low in two others, and normal in only one.

DISCUSSION

Improvement in radiographic technique, including the lateral view of the hip, facilitates assessment of the lesion and observation of reconstruction. In some instances the necrosis appeared to affect only the anterior part of the capital epiphysis and was very limited; it was

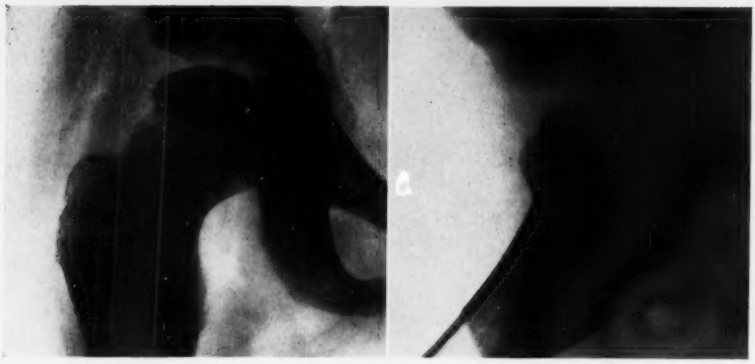

FIG. 3

FIG. 4

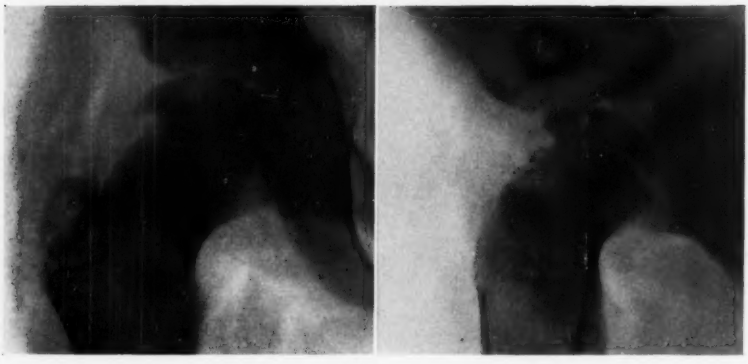

FIG. 5

Case 2. Figure 3—At commencement of treatment. Aged five years. The epiphysis is dense, has a double articular margin and shows early anterior rarefaction in the lateral projection. Figure 4—Seven months later. The stage of fragmentation. There is a tongue-shaped translucent area in the anterior segment of the femoral head. Figure 5—Five months later. Early reconstruction. The dense bone has been almost entirely removed and new bone formation is seen in the front of the head.

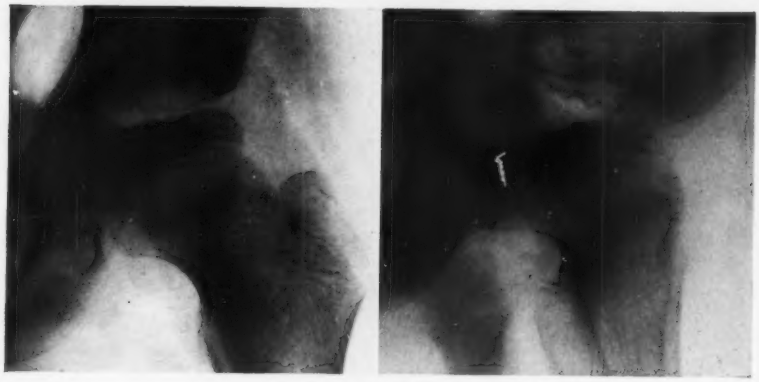

FIG. 6

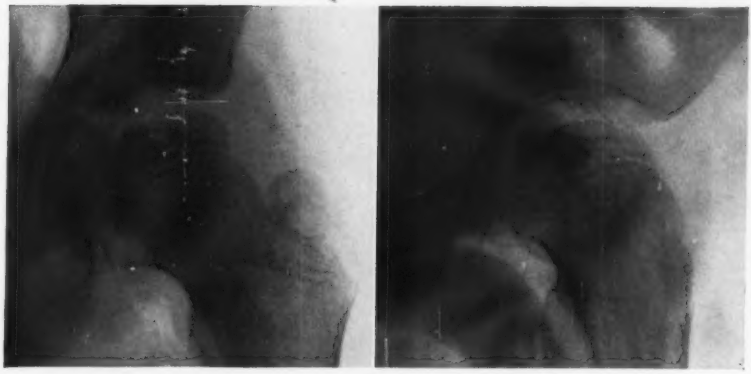

FIG. 7

FIG. 8

Rapid reconstruction of an anterior lesion. Figure 6—Five months after the onset of symptoms. A large anterior segment of the femoral head appears abnormally dense and shrunken. Figure 7—Four months later. Most of the dense bone has been removed and replaced already by bone of normal appearance. Figure 8—Three months later. Reconstruction is practically complete.

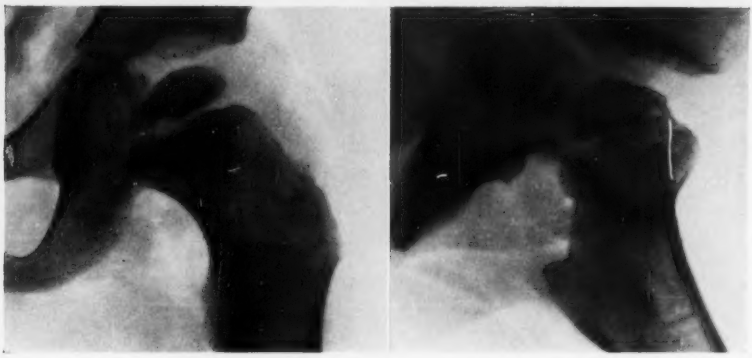

FIG. 9

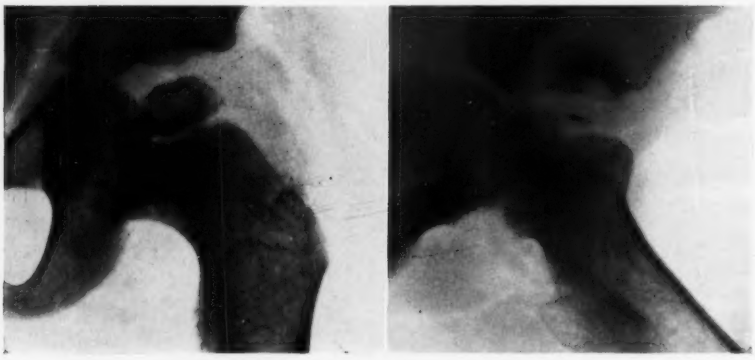

FIG. 10

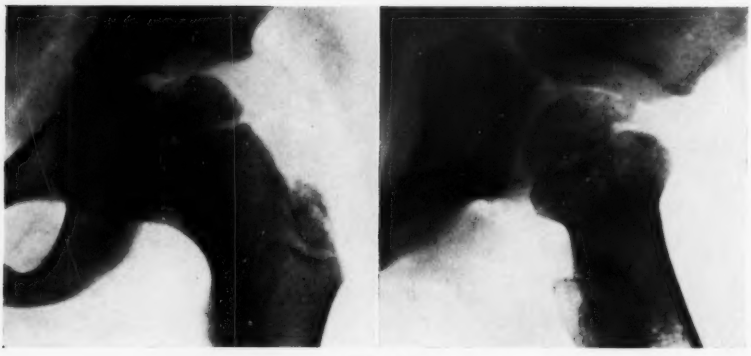

FIG. 11

Case 11. Figure 9—At the commencement of treatment. Aged six years. There is rarefaction of the metaphysis mainly in its anterior third, with early necrosis of the epiphysis. Figure 10—Six months later. The metaphysial lesion has healed and the overlying part of the head has become rarefied. Figure 11—One year after commencement of treatment. Reconstruction is well advanced. Most of the anterior segment of the head appears to have been filled in by new bone.

repaired so completely and so rapidly that it seems probable that it might have recovered without treatment. Obviously a more extensive change requires longer treatment. There is no point in having repeated radiographs, and they may in fact be harmful. One examination about four months after the beginning of treatment, the second at the tenth month, and the third at the sixteenth is about sufficient.

It would be gratifying if the pattern of necrosis threw some light on the etiology. Many theories have been advanced, including infection of the hip by organisms of attenuated virulence (Platt 1922, Phemister 1921) and latent hypothyroidism (Cavanaugh, Shelton and Sutherland 1936). But the progress of the condition is not like that of an infection, and careful investigation by serum protein-bound iodine did not support the theory of hypothyroidism (Beiler and Love 1956).

Probably avascular necrosis of the femoral head similar to that which occurs after "slipping" of the epiphysis or fracture of the neck (Axhausen 1923) has been the most attractive theory. But it would be difficult to reconcile a vascular explanation with the pattern observed in this series. It would be necessary to suppose that a large part of the epiphysis

FIG. 12

Case 19. Aged eleven years. After two years' treatment. Situated in the anterior half of the femoral head is a segment of dense bone which is displaced below the level of the normal articular margin. There is very little attempt at reconstruction.

was supplied with blood by a single artery, the blocking of which produced avascular necrosis. Such a supposition is not supported anatomically. Between the age of three years and adolescence the blood supplied to the femoral head travels in the posterior retinacular vessels, which are arranged in superior and inferior groups (Wolcott 1943). The anterior retinacular arteries are small and inconsistent (Tucker 1949) and their blockage could not be expected to cause extensive changes in the head. Trueta (1957) has renamed the posterior retinacular vessels the lateral epiphysial arteries. He stated that these vessels enter the outer segment of the femoral head, slightly posteriorly, and close together, and that the lateral epiphysial arteries are the only source of blood to the head between the ages of four years and eight or nine years, after which the arteries of the ligamentum teres make some contribution to the supply of the head. But one may assume that circulation in the cancellous bone of the head is as free as in other cancellous bone: in other words, once blood has reached one part of the head it can reach all parts. It is of interest that Burrows (1941) was unable to accept arterial block as a cause of Perthes' disease. He concluded that: 1) coxa plana proves histologically to be a condition of necrosis of bone followed by repair; 2) the necrosis differs from ordinary aseptic

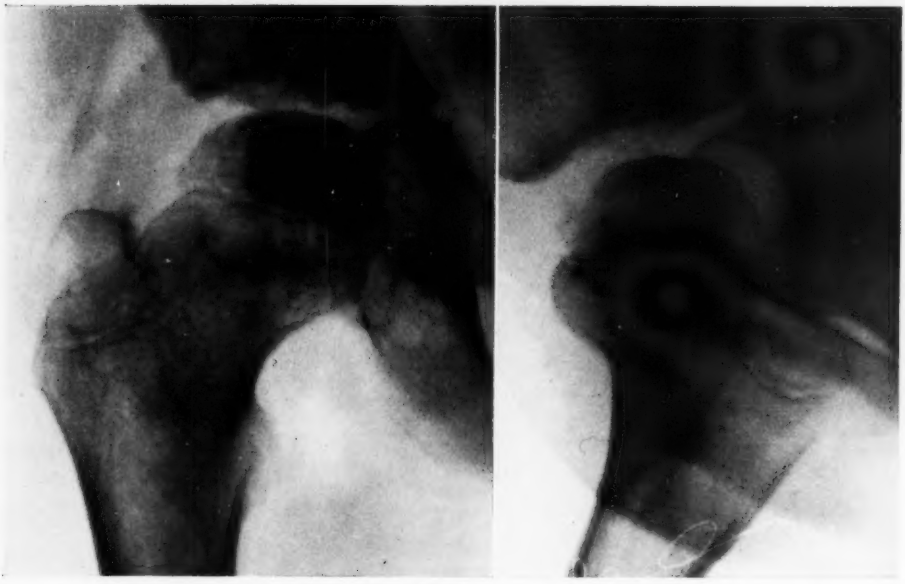

FIG. 13

FIG. 14

Case 18—Aged seven years at commencement of treatment. Figure 13—The anterior half of the femoral head is abnormally dense but shows a linear rarefaction. Figure 14—Six months later. The dense bone has been removed almost completely from the front of the head.

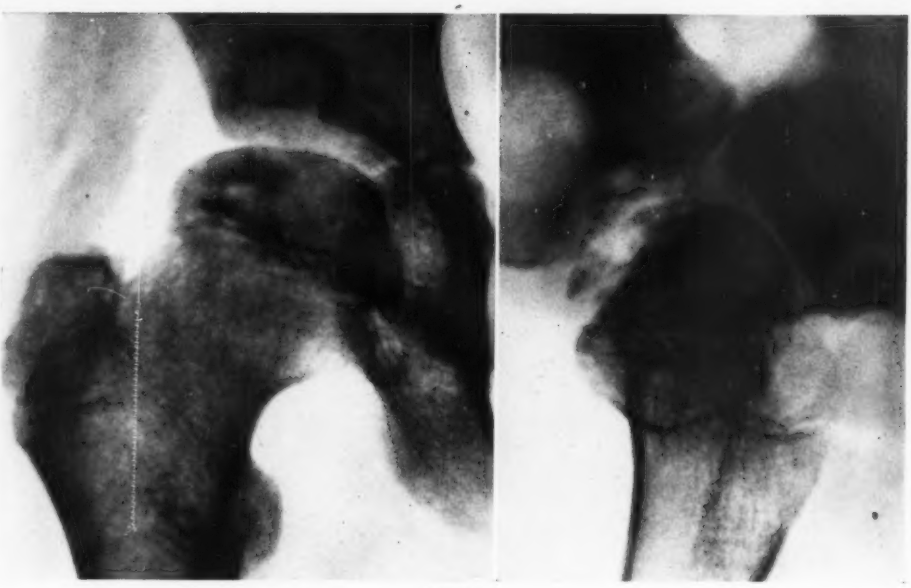

FIG. 15

FIG. 16

Case 18. Figure 15—Nine months after commencement of treatment. Reconstruction is beginning in the periphery of the head. Figure 16—Two years after commencement of treatment. Reconstruction is complete after two and a half years. Epiphysial index=40.

FIG. 17

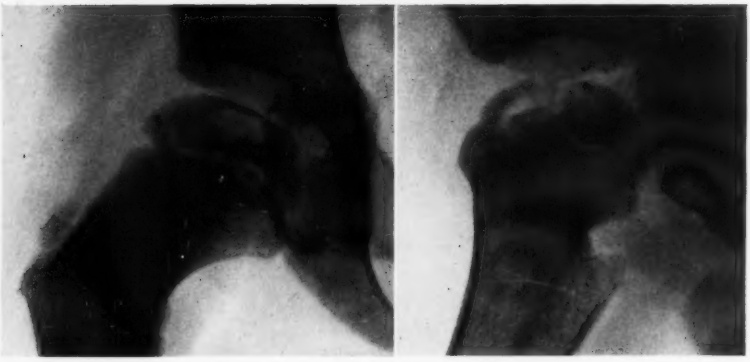

FIG. 18

FIG. 19

Case 3—Aged five years at diagnosis. Figure 17—Flattening of the head of the femur is marked. The anterior part of the head is rarefied. Figure 18—One year later. The head of the femur has increased in depth. Reconstruction of the anterior segment is proceeding both at the articular margin and from behind forwards. Figure 19—After three years. Reconstruction is complete. Epiphysial index = 36.

FIG. 20

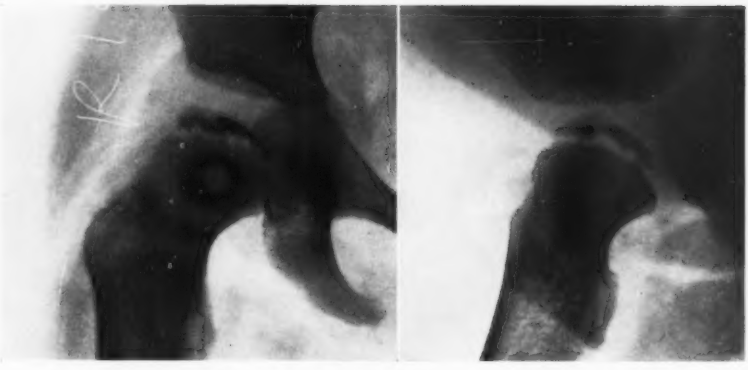

FIG. 21

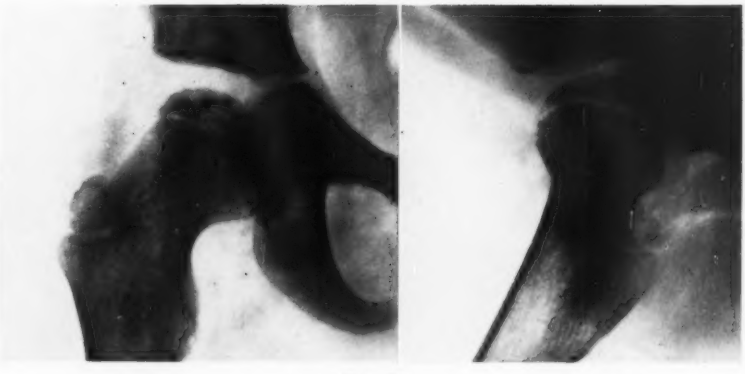

FIG. 22

Case 21—Aged two and a half years at commencement of treatment. Figure 20—The entire head of the femur appears to be flattened and dense. A metaphysial lesion can be seen in the centre of the neck. Figure 21—Three months later. Fragmentation of the whole head of the femur is advanced. Figure 22—A year and a quarter after commencement of treatment. The head of the femur is being reconstructed and is increasing in depth.

necrosis in showing lysis of trabeculae; 3) infection cannot be excluded as a cause of the lysis, but is very improbable; and 4) a possible cause is either venous obstruction or haematoma.

There might well be a similarity between the pathogenesis of Perthes' disease of the hip and that of Freiberg's (or Panner's) disease of the second metatarsal bone. Both show the same basic histological changes (Axhausen 1923): both affect an epiphysis in a segmental pattern, and both tend to heal spontaneously and leave the epiphysis deformed (as if a young mushroom had become middle-aged). Smillie (1957) considered that Freiberg's disease is a form of osteochondritis dissecans. In the present series the radiographic appearance in the femoral heads of the older patients bore a resemblance to osteochondritis dissecans, but both Perthes' disease and osteochondritis dissecans of the hip have been reported in the same patients (Fairbank 1933, Ratliff 1956). Separation of the affected part to form a loose body does not apparently occur in either condition. This is probably accounted for anatomically (Guilleminet and Barbier 1957). No doubt as our opportunities for observation increase so will our understanding, and ultimately it may be found that Perthes' disease, Freiberg's disease and osteochondritis dissecans all have a common etiological factor, operating at differing ages and so with differing effects.

SUMMARY

1. The progressive radiographic changes in twenty-five patients suffering from Perthes' disease of the hip are described.

2. The prognostic value of lateral views of the hip is emphasised, and the present concepts of pathogenesis in the light of recent observations are discussed.

My thanks are due to Professor Bryan McFarland for much help in the preparation of this paper; also to Mr G. E. Thomas, Mr G. V. Osborne, Miss Norah Walker and many others.

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VERTEBRA PLANA (CALVÉ)

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Vertebra plana first became known as an entity in 1924 when Calvé described it at the meeting of the British Orthopaedic Association at Bologna. In the following year he published his case and one discovered by Brackett under the title " A localized affection of the spine suggesting osteochondritis of the vertebral body, with the clinical aspect of Pott's disease."

Sundt (1935) reviewed the world's literature and found twenty-one reported cases, but some of these he considered were not true examples. Compere, Johnson and Coventry (1954) presented four cases of vertebra plana caused by eosinophilic granuloma. Compere added: " I would like to make it clear that we are not by any means suggesting that it (eosinophilic granuloma) is the only cause of vertebra plana, but it is the only one that we know about."

The world's literature has been searched by one of us (W. J. W.), and we have analysed this material in the hope of obtaining further information about the nature and cause of vertebra plana[1–133]. This search brought to light ten cases reported in the Japanese literature that have not been noted by other European authors.

It appears from our review of previous work that the radiographs in the case to be reported are unique, because it is the first time that a complete series of films has been obtained showing the remarkable speed with which the vertebra may collapse. Our serial films also show changes in the pedicles and in one transverse process which have received little attention in the literature: Bonomini (1937), Fawcitt (1940), Neyroud (1947) and Rocher (1934) are the only other authors to have reported such changes.

The progress of the disease in the body, pedicles and transverse process in this case is so like that seen in the Calvé-Legg-Perthes disease of the hip that we still feel that one cause of vertebra plana is aseptic necrosis.

CASE REPORT

A quarter-caste Maori girl aged three years was admitted to the Hutt Hospital in May 1953. Seven days before she had complained of pain in the back. Four days later, while getting up from the sitting position, she fell forward screaming and then doubled up. This attack lasted for five minutes and she was then quite at ease. The next morning she had a similar attack of pain, and the following day two more. These came on while she was walking about. On the day of admission she had a further attack lasting about ten minutes. Apart from these episodes she ran about and played normally.

An unusual feature of the history was that on the day of admission she had passed two stools consisting of bloody mucus. Her general practitioner noticed " red currant jelly " on the examining finger and sent her into hospital with suspected acute intussusception. There was no history of recent injury or infection, or of tuberculosis in the family.

On examination it was noted that she spent most of her time lying in bed and resented being moved. Now and then she seemed to have pain in her back, but she would get up and walk about the cot for short intervals. She would lie on her stomach or left side when resting. No other abnormality was found. Radiographs showed loss of the lumbar curve but no other abnormality (Fig. 1).

During the next few days the back pain seemed to be worse, and a week after her admission she was unwilling to walk at all. There was intense spasm of the posterior spinal muscles, and on attempted movement she screamed with pain. There was no swelling in the lumbar

FIG. 1

FIG. 2

Figure 1—Initial radiograph showing normal depth of the fifth lumbar vertebra. Figure 2—Eight days after first examination: partial collapse of fifth lumbar vertebra with increased depth of the disc spaces above and below it.

FIG. 3

FIG. 4

Figure 3—Fifteen days after first examination. The vertebral body has collapsed to a wafer. The disc spaces are deep. The end plates of vertebral body are intact. Figure 4—Condition at six weeks. Note that the pedicles are atrophic.

region and no definite tenderness. Further radiographs taken eight days after the first examination showed collapse of the body of the fifth lumbar vertebra, with increase in the depth of the adjacent spaces (Fig. 2). Re-examination another week later showed the body of the fifth lumbar vertebra now as a thin disc. The superior and inferior end plates appeared intact and there was a further increase in the depth of the disc spaces above and below it. There was some loss of bone substance in the pedicles (Fig. 3). Radiographs of the skull, thoracic spine, chest, pelvis and upper femoral and humeral shafts did not show any other lesion.

Investigations—Haemoglobin was 15 grammes per cent and the leucocyte count showed 9,300 per c/millimetre (neutrophils 67 per cent, lymphocytes 31 per cent, monocytes 1 per cent,

FIG. 5

FIG. 6

Figure 5—Seven months. Reconstruction is taking place, with new bone formation about the dense wafer. The pedicles are still smaller than those of the vertebrae above and below. Figure 6—Five and a half years after onset. Repair is well advanced. The increased antero-posterior diameter is well seen and the body is trapezoid.

eosinophils 1 per cent). The erythrocyte sedimentation rate was 29 millimetres/hour: Mantoux test was negative to 1:1,000. The Wassermann and Kahn reactions were negative.

Treatment and progress—The child was rested on a plaster bed, with immediate complete relief from pain. After six weeks she began to lean up on her elbow whenever she had the chance; so presumably all the pain had gone. Immobilisation was continued for nine months, after which she was allowed up in a spinal brace. Serial radiographs during this time showed evidence of gradual healing of the lesion, with renewed growth of the vertebral body (Figs. 4 to 6).

The child has been re-examined regularly and has remained free from pain. When she was last seen, in October 1958, the lumbar spine was rather flat but there was no suggestion of a gibbus. The spine was freely mobile in all directions. The last radiographs (1958) showed the body of the affected vertebra to be about half the normal depth (Fig. 6). The disc above was

of the same height as that between the fourth and fifth lumbar vertebrae, and that below was a little narrower. The antero-posterior diameter of the vertebral body was 40 millimetres, compared with 28 millimetres for the body of the adjacent vertebral body. Thus restitution to normal shape cannot be expected in this case.

DISCUSSION

The flattened body characteristic of the fully developed Calvé's disease is a radiological appearance that may have several causes. It has been believed, on good grounds, that osteochondritis was the commonest cause, but others that have been reported include

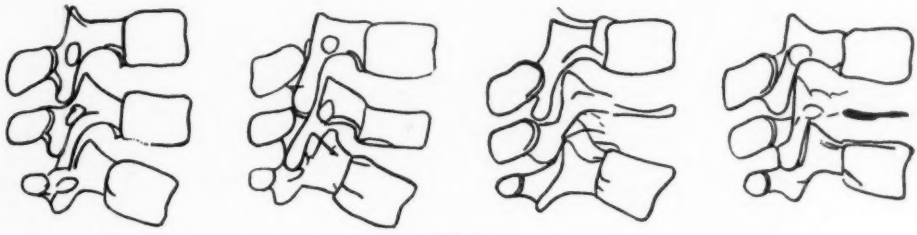

FIG. 7
Diagrams showing the early changes. They correspond to radiographs in Figures 1 to 4.

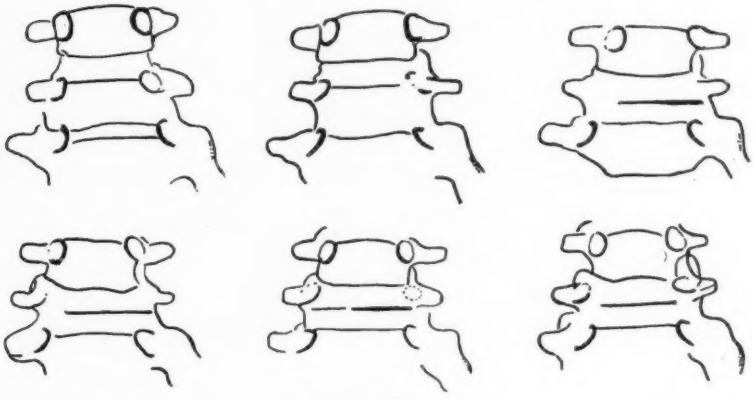

FIG. 8
Diagrams showing changes in the alignment, shape and density of pedicles in early stages of the disease.

Hand-Schüller-Christian disease, Hodgkin's disease, osteogenesis imperfecta, hyperparathyroidism, unidentified malignant disease, eosinophilic granuloma, and injury in tetanus.

In about a third of the cases there has been history of sudden onset; in the remainder the onset has been gradual. The speed of development is no help in diagnosis because the radiographic appearance is the same in each type. A few patients have shown a fusiform paravertebral shadow extending for an inch or two above and below the collapsed vertebra. The nature of this shadow remains uncertain; it is not regularly associated with any particular type of case. It appears early, it never calcifies and it persists for weeks.

The continuing uncertainty about the pathology in most cases of Calvé's disease is due to the infrequency of histological study of material from the affected vertebrae. Mezzari's (1938) report was of limited value because the study was made eighteen months after the

onset of the disease and it was already in a late healing stage. Mezzari concluded that the process was a malacia with aseptic necrosis.

Compere, Johnson and Coventry (1954) found that eosinophilic granuloma was the cause in four consecutive cases—a very suggestive observation. One may question whether biopsy is in the best interests of the patient, but it is the only way of settling the issue with any certainty, and if a few more cases can be investigated the same way the problem should be solved.

SUMMARY

1. A case of vertebra plana (Calvé) is described and serial radiographs throughout the course of the disease are presented.

2. The initial radiographs showed a vertebra of normal depth which collapsed to a thin disc in fifteen days. Since the symptoms had begun twelve days before the first examination the total time taken to reach this stage was twenty-seven days.

3. The literature has been reviewed for evidence of the underlying pathology of vertebra plana. In the case described biopsy of the affected vertebral body was not carried out, and thus the nature of the underlying change could not be determined.

We wish to thank Dr J. Cairney, Miss I. Garai, Dr G. C. Geel, Dr D. Levinsohn, Dr P. Wrightson and Mr P. Klarwill for translations of many of the papers quoted. We also wish to thank Sir Harry Platt, Mr T. Price, Dr P. M. Davies and Dr J. B. Fawcitt for clinical details of some of their patients, and Professor B. McFarland and Professor I. Miki for their advice. Dr J. M. Watt was responsible for the initial care of the patient before she was transferred to the Orthopaedic Department.

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SPINA BIFIDA OCCULTA WITH ENGAGEMENT OF THE FIFTH LUMBAR SPINOUS PROCESS

A Cause of Low Back Pain and Sciatica

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Although spina bifida occulta has often been blamed in the past for backache and sciatica, I have believed neither that it was a common source of these troubles, nor that the fibrous band that closes the sacral breach is a cause of nerve root compression, as has been suggested by some authors. I have often explored a concomitant sacral defect while operating for a disc lesion, and have never found even the remotest possibility that this membrane could press on the contents of the spinal canal.

Nevertheless spina bifida occulta may be associated with low back pain, because of the absence of the first sacral spinous process and the ligaments that normally run between it and the spinous process of the fifth lumbar vertebra. In the normal spine extension is often limited by the apposition of the fifth lumbar and first sacral spinous processes; because of the absence of the latter in spina bifida occulta there may be hypermobility in extension, and this may itself cause low back pain or sciatica.

THE ENGAGED SPINA BIFIDA AS A CAUSE OF PAIN

It is the purpose of this paper to show that pain can be caused in spina bifida occulta by the impingement of the spinous process of the fifth lumbar vertebra on either the stumps of the laminae of the first sacral vertebra or the fibrous band that lies between the stumps.

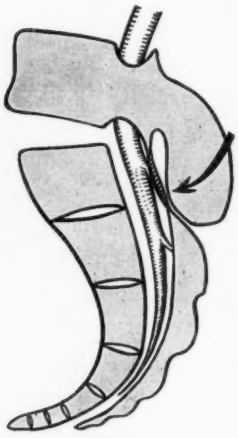

FIG. 1

A diagram to illustrate the manner in which the spinous process of the fifth lumbar vertebra can impinge on the fibrous membrane that closes the breach in a first sacral spina bifida.

This mechanism of pain production is more likely to occur when the increased range of extension is accentuated by a more than usually horizontal sacrum, an abnormally long fifth lumbar spinous process, or lax spinal ligaments—in particular the anterior longitudinal ligament, which should control hyperextension. This pain-producing process in spina bifida is an entity, and is to be distinguished from hypermobility alone as a cause of pain (Fig. 1). It has been observed in fifteen patients.

It is possible that, in the extreme case, the fifth lumbar spinous process may compress the nerve roots in the cauda equina through the occluding membrane. Occasionally (in five of our patients) a rudimentary and mobile spinous process of the first sacral vertebra is pressed upon and in turn presses into the dura and underlying nerves (Fig. 2).

MATERIAL

Table I shows the treatment and operative findings in the patients in this series. I first suspected that impingement of the fifth spinous process on a spina bifida could cause pain during an operation in 1952 for a disc lesion at the fourth lumbar level, in a

patient who also had a wide first sacral spina bifida clearly shown in the rather unusual radiograph (Fig. 3). The spina bifida was explored during the operation, and the fifth lumbar spinous process was found to be firmly adherent to the fibrous membrane, the deep surface of which was also adherent to the dura beneath it.

TABLE I

TREATMENT AND OPERATIVE FINDINGS

Number of patients	15
Conservative treatment	4
Operative treatment	11
Combined operation (treatment of the spina bifida and fusion)	3
Findings at operation	
Adherence of fifth lumbar spinous process to the fibrous membrane	7
Loose body interposed (rudimentary first sacral process)	4
Adherence of fibrous membrane to dura	8

Since then, fourteen other patients have been studied in whom the pain could be attributed to the impingement or engagement of the fifth spinous process on a sacral spina bifida, and eleven came to operation. Four were reported by the author at a meeting of the Sociedad Argentina de Ortopedia y Traumatologia in July 1956. At that time no paper had been

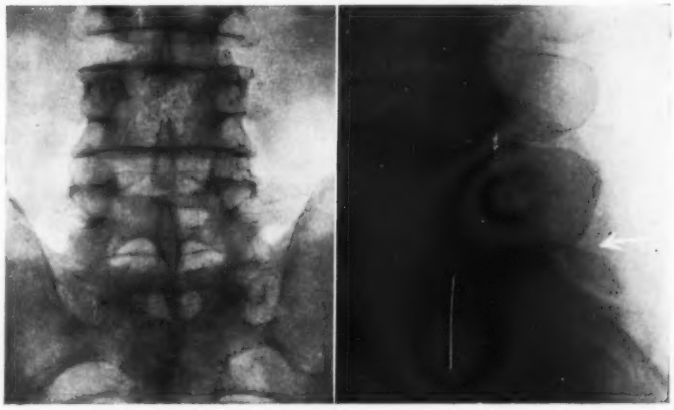

FIG. 2

Radiographs of a patient with spina bifida occulta in whom the remnant of the first sacral spinous process is present. This can be pressed into the dura by the spinous process of the fifth lumbar vertebra when the lumbar spine is extended.

discovered that dealt exclusively with this subject, but since then other articles have been found in which reference is made to it.

Ferguson (1934) mentioned the possibility of congenital fusion of the fifth lumbar vertebra and a rudimentary first sacral spinous process as a cause of pressure through the sacral laminar defect. Williams (1953) referred to this mechanism without reporting cases. Gill and White (1955) also referred to this type of pressure-producing mechanism, and detailed the symptomatology, but did not report on any patients.

CLINICAL FEATURES

There are two different types, depending on whether or not there is nerve root compression. *Spina bifida with impingement of the fifth spinous process without root compression*—This is probably the more common type. In spinal extension the fifth spinous process presses against the membrane that closes the spina bifida, or against its stumps, provoking a pain in the lumbo-sacral region that can radiate towards one or both lower limbs. The pain is deep and diffuse, and there is no loss of reflexes, sensation or mobility. The most important clinical sign is pain produced by pressing on the fifth lumbar spinous process and hyperextending the spine, especially with the patient standing. This was clearly demonstrated in one patient, a football player, who had no discomfort while practising physical exercises or playing football, but on prolonged standing complained of pain and numbness in both thighs. Most of the patients come into this group even though some were found at operation to have a dura adherent to the occluding membrane.

FIG. 3

A radiograph of an unusual spina bifida occulta. The operative findings suggested that pain was being produced at this site.

Spina bifida with impingement of the fifth spinous process with root compression—Although theoretically the possibility of compression of the cauda equina by the fifth spinous process pressing through the fibrous membrane is obvious, only two patients showed signs of nerve root irritation. One patient, who had suffered pain continuously for twenty years, had an absent ankle jerk; in another there were sensory changes in the legs. In eight other operations adhesions were found between the deep aspect of the membrane and the dura, at the level at which the spinous process was pressing, so severe and extensive in three that freeing the dura was difficult. None of these patients showed any neurological abnormality.

ASSOCIATED LESIONS

The presence of some other condition than the spina bifida must not be overlooked, such as an intervertebral disc lesion or another congenital malformation. Three of the patients in this series were operated on for a disc lesion between the fourth and fifth lumbar vertebrae as well as a spina bifida; one of them also showed sacralisation of the fifth lumbar vertebra. In all three the spine was fused after treatment of the spina bifida.

It must be noted that narrowing of the lumbo-sacral disc favours the development of impingement, in the same way as the horizontal sacrum, or the existence of a long fifth lumbar spinous process, by shortening the distance between the fifth spinous process and the sacrum.

RADIOLOGICAL CHANGES

Antero-posterior and lateral radiographs should be taken; the Ferguson position should be used to project the sacrum in a vertical position and show the full extent of the spina bifida. When there is impingement, the fifth lumbar spinous process projects over the breach of the sacrum. Three different radiological types of this anomaly can be recognised (Figs. 4 to 6). In type 1 there is a wide breach in the sacrum, with the fifth lumbar spinous process

projecting over it; in type 2 the breach is small and the spinous process engages the stumps of the spina bifida; in type 3 there is a loose bone that represents the rudimentary first sacral spinous process. Lateral radiographs should also be taken with the patient standing in flexion and extension, to show the impingement of the fifth spinous process on the spina bifida (Figs. 7 and 8).

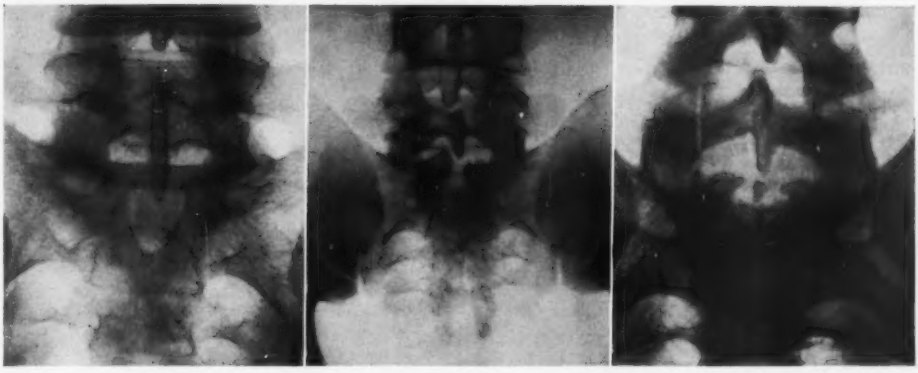

FIG. 4 FIG. 5 FIG. 6

The three different radiological types of spina bifida occulta. Figure 4 shows type 1, a wide breach in the sacrum. Figure 5, type 2, a narrow breach with stumps of the lamina on which the spinous process above impinges. Figure 6, type 3, a rudimentary first sacral spinous process is present.

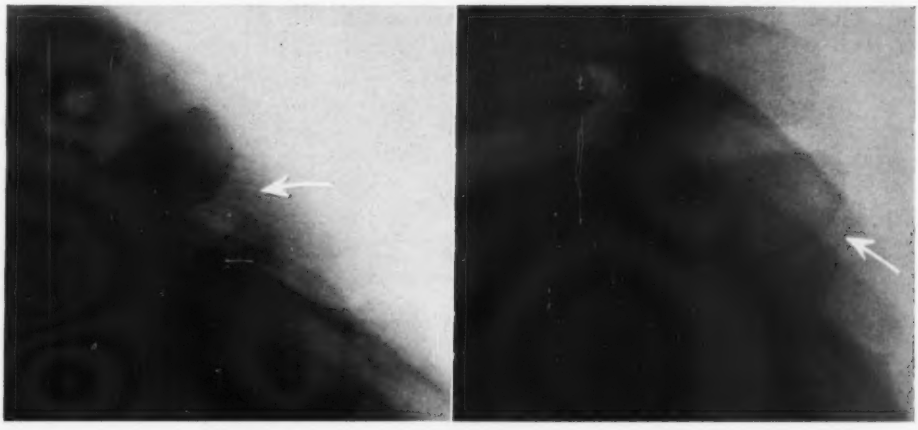

FIG. 7 FIG. 8

Flexion and extension radiographs to show impingement of the fifth lumbar spinous process on a rudimentary first sacral spinous process.

TREATMENT

Patients with mild symptoms can be treated with flexion exercises to reduce the hyperextension of the lumbar spine.

In most patients with severe symptoms excision of the fifth lumbar spinous process and the fibrous membrane is necessary.

In this series the usual procedure was to expose the spina bifida, and to define its limits. The fifth lumbar spinous process was removed by cutting it off at the base, and by separating the adhesions between it and the fibrous membrane across the spina bifida. The fibrous

membrane was then excised, care being taken in case it was adherent to the dura mater. If necessary the stumps of the defective sacral lamina were also removed. The gap that remains may be filled with a flap of muscle. Arthrodesis is performed if there is an abnormal degree of mobility of the fourth and fifth lumbar vertebrae.

RESULTS

Table II shows the results in the eleven patients treated by operation who were observed for more than one year afterwards.

TABLE II

RESULTS OF OPERATION FOR SPINA BIFIDA

Excellent (symptom free)	8
Good (few symptoms in the lumbo-sacral region)	2
Fair (persistence of some lumbo-sacral pain) .	1

SUMMARY AND CONCLUSIONS

1. Fifteen patients with spina bifida occulta are described in whom the fifth lumbar spinous process was pressing on the fibrous membrane that closes the spina bifida, or on the bony stumps of the defective lamina.

2. That this is a cause of low back pain, with or without pain referred to the lower limbs, is supported by the findings at operation and the results of treatment.

3. Eleven patients were treated by operation; in each the spinous process of the fifth lumbar vertebra pressed against the spina bifida, either directly or through the vestigial remnant of the first sacral spinous process.

4. In eight cases the fibrous membrane was adherent to the dura mater; in one case the nerve roots were adherent.

5. Excision of the fifth lumbar spinous process and the membrane across the breach of the spina bifida was an effective method of treatment.

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EARLY DRAINAGE OF PARASPINAL TUBERCULOUS ABSCESSES IN CHILDREN

A Preliminary Report

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The dreadful results of tuberculosis of the thoracic spine in children are too well known all over the world. Even if the disease becomes arrested the child's life remains threatened by the thoracic deformity and by the remaining large, partly calcified abscess. Apart from the risk of recrudescence of activity of the disease, the mechanical effects of the deformity threaten the function of the heart, the lungs and the spinal cord.

Chemotherapy and earlier diagnosis have improved the outlook, but something more than these is needed if an abscess of any size is present when the child is first seen. It is, however, still undecided how much more should be done. Stevenson's (1954) question as to how best we may apply modern combined treatment to a child of three with a globular abscess remains unanswered. This paper will try to give an answer, even though that answer is to be regarded as preliminary and perhaps only applicable to Chinese children.

The literature of combined orthopaedic, chemotherapeutic and operative treatment in children is surprisingly scanty. Wilkinson (1954) mentioned five children with spinal tuberculosis treated by chemotherapy and curettage of the vertebral bodies, but he did not state the area of the spine that was affected. He had four successes and one failure; the average duration of treatment was twenty-six months. Dobson's (1956) series included fifteen patients, adults and children, in whom costo-transversectomy was performed for thoracic Pott's disease with tense perispinal abscesses. His results were good and " in only three cases have sinuses followed, all in adults with extensive generalised tuberculosis." Hodgson and Stock (1956) gave a preliminary report of their radical operation for thoracic disease and for Pott's paraplegia in forty-eight patients, of whom seven presented early thoracic disease while under the age of twelve. Roaf (1956) reported the successful treatment of three Indian infants under the age of two. All three had paraplegia, and all recovered movement after costo-transversectomy and curettage of the skeletal focus. Griffiths, Seddon and Roaf (1956) described twenty-eight cases of costo-transversectomy for paraplegia, but only five of these operations were performed for early disease in children under twelve. In three of these five the paraplegia made a rapid recovery, but there was later relapse of the paralysis in two. The literature is thus not only scanty, but it is largely concerned with paraplegia and with recovery from paralysis rather than with cure of the bony focus.

This scarcity of reference to early operative treatment of the disease in children is a reflection of the recent decline in its incidence in Western Europe and in North America. In Singapore, active thoracic spinal tuberculosis is still common enough to present a large therapeutic problem, but the reluctance of Chinese parents to bring their children to hospital means that we have all too little opportunity of studying early cases. Too many patients with early disease are taken to unqualified practitioners (the " sinseh ").

A SERIES OF FOURTEEN CASES

A case was considered " early " if it showed 1) a short history, less than a year, and 2) an abscess shadow in the radiograph which had sharp borders; these shadows were dense and fusiform or globular in all cases.

I have collected fourteen such cases in Chinese children under twelve years old in the five years 1952–56. Costo-transversectomy or antero-lateral decompression was performed forty-one times in children during this time, but in only fourteen could the term " early case " be applied. Table I gives details of these fourteen.

TABLE I

DETAILS OF FOURTEEN CASES OF EARLY THORACIC SPINAL TUBERCULOSIS TREATED BY COMBINED CHEMOTHERAPY, IMMOBILISATION AND COSTO-TRANSVERSECTOMY

Case number	Age (*years*)	Sex	Duration	Level	Paraplegia
1	2	F	4–5 months	T.5–7. Large abscess; sharp borders	Yes
2	5	M	6 months	T.7–10. Large abscess; sharp borders. Anterior erosion T.11–12	Yes
3	12	F	12 months	T.12–L.1. Large abscess; sharp borders	Yes
4	2	M	1 week	T.6–7. Large abscess; sharp borders. Anterior erosion T.5	No
5	3	F	8 months	T.5–7. Large abscess; sharp borders	No
6	3	F	11 months	T.9–10. Large abscess; sharp borders. Anterior erosion T.11	No
7	11	F	2 weeks	T.5–6. Large abscess; sharp borders	Yes
8	2	M	1 month	T.9–10. Large abscess; sharp borders. Anterior erosion T.6–8	No
9	9	F	3 months	T.8–9. Abscess with sharp borders. Anterior erosion T.7 and T.10	Yes
10	8	M	4 months	C.7–T.2. Large abscess; sharp borders. Anterior erosion C.6 and T.3–5	Yes
11	5	F	6 months	T.8–9. Large abscess; sharp borders. Anterior erosion T.6 and T.7	Yes
12	4	M	10 months	T.9–11. Large abscess; sharp borders	No
13	3	F	8 months	T.6–7. Large abscess; sharp borders	No
14	2	M	4 months	T.1–2. Large abscess; sharp borders	Yes

Their ages ranged from two to twelve years (Fig. 1). Three of the four older children had tuberculous disease elsewhere as well as in the thoracic spine.

In all fourteen children chemotherapy was given according to the routine advocated by Wilkinson (1954). The dosage is shown in Table II. Chemotherapy was started immediately after admission to hospital so that operation should be performed under established antibiotic cover (Orell 1956).

Costo-transversectomy was performed as soon as possible after the patients had become accustomed to their anterior and posterior plaster shells. In four cases, however, other lesions demanded urgent treatment, and thus delayed operation for the spinal lesion.

THE OPERATION

The main purpose of the operation is to release pus, which in these early cases may gush out under considerable pressure. Necrotic matter has been removed only when it has presented spontaneously. Curettage has not been performed.

TABLE I—*continued*

Other lesions	Date and nature of operation	Remarks
—	10.9.53 Costo-transversectomy	Abscess disappeared. Paraplegia resolved. No further destruction
—	27.11.53 Costo-transversectomy	Abscess disappeared. Paraplegia resolved. No further destruction. T.12 nearly normal
Tuberculosis of lung (upper left zone)	5.2.54 Costo-transversectomy 21.5.54 Spinal graft	Abscess disappeared. Paraplegia resolved
Primary complex	1.10.54 Costo-transversectomy	Abscess disappeared
—	8.5.55 Costo-transversectomy 25.7.56 Spinal graft	Abscess disappeared. No further erosion
Tuberculosis of lung and shoulder. Tuberculous adenitis	10.5.55 Costo-transversectomy	Abscess disappeared. T.9–11 fused in 6 months
Pleurisy. Phlyctenular conjunctivitis	21.5.54 Costo-transversectomy 20.1.55 Spinal graft	Abscess nearly disappeared. Paraplegia partly resolved
—	6.10.55 Costo-transversectomy 16.4.56 Spinal graft	Abscess disappeared. Anterior erosion T.6–8 disappeared; vertebrae reshaping
Old tuberculosis of knee	21.11.55 Costo-transversectomy 1.3.56 Laminectomy 5.4.56 Spinal graft	Abscess disappeared. Paraplegia resolved. Anterior erosion disappeared
—	28.2.56 Costo-transversectomy	Abscess disappeared. Paraplegia resolved
—	28.2.56 Costo-transversectomy	Abscess disappeared. Paraplegia resolved
Severe tuberculosis of both lungs	19.4.56 Costo-transversectomy	Abscess disappeared
Tuberculosis of L.4–5 vertebrae	27.4.56 Costo-transversectomy	Abscess disappeared. T.6 and T.7 fused after 7 months. Sequestrum revascularised and fused
—	31.7.56 Costo-transversectomy	Abscess disappeared. Paraplegia resolved

This purpose can be fulfilled by means of a straightforward costo-transversectomy. After removal of the pus and of any presenting debris the cavity is irrigated with normal saline and hydrogen peroxide, a gramme of streptomycin powder is inserted, and the wound is closed forthwith.

Our patients have stayed in hospital for an average of about a year after operation. It is hoped that this time will be reduced in the future, but in Singapore the length of stay in hospital is largely influenced by home conditions and other social factors. In some cases the time spent in hospital was also lengthened by the treatment necessary for disease in other parts of the body.

RESULTS

Abscess—The abscess disappeared completely in thirteen cases. In one (Case 7) there is still a narrow " strip " visible in the radiograph, but in this case the operation had to be postponed for six months because of the state of the lungs.

Vertebral changes—Bony fusion of the affected vertebrae occurred spontaneously within six to eight months in four cases.

Erythrocyte sedimentation rate—A typical response of the erythrocyte sedimentation rate is shown in Figures 2 and 3. Rest and chemotherapy produce an immediate fall in the rate;

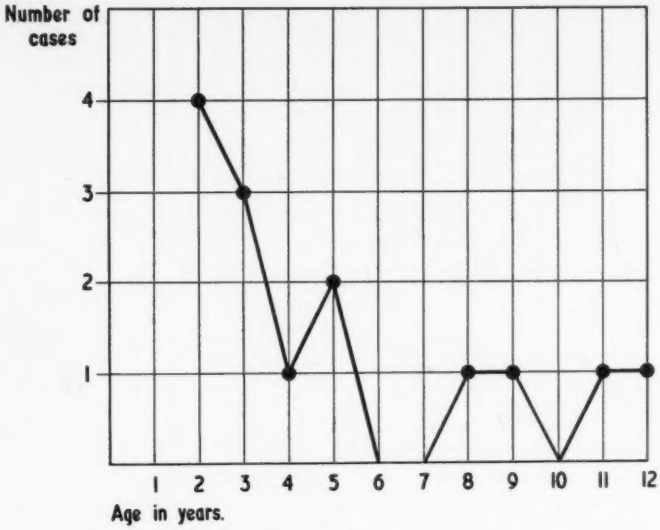
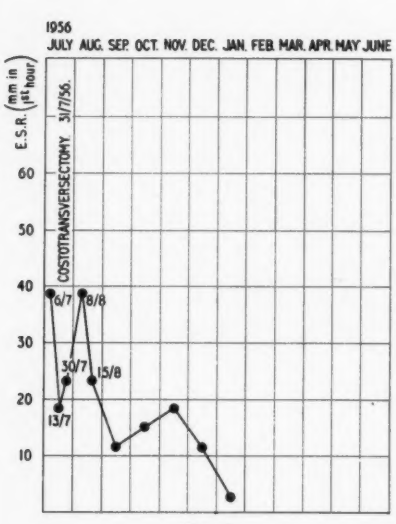


FIG. 1
Ages of the fourteen children in the series. Ten children were five years old or less.



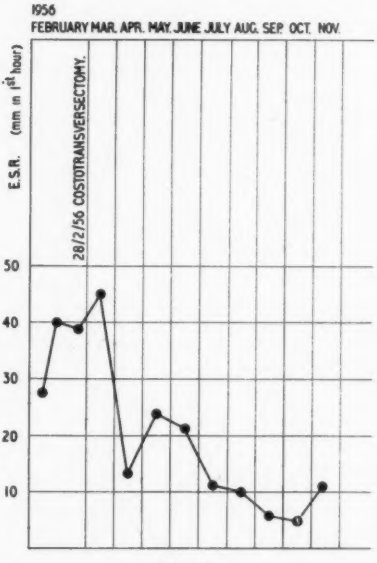


FIG. 2 FIG. 3

Figure 2—Case 14. A typical response of the red cell sedimentation rate after costo-transversectomy.
Figure 3—Case 10. Another such response.

operation accelerates it again, but is speedily followed by a fall to normal. The same tendencies are shown even in cases complicated by active lung disease.

TABLE II

SCHEME AND DOSAGE OF CHEMOTHERAPEUTIC AGENTS EMPLOYED IN THIS SERIES

Age (*years*)	Streptomycin		Isonicotinic acid hydrazide. Daily	Para-amino-salicylic acid. Daily
	Daily	Total		
Under 5	½ gramme	67 grammes	4 milligrams/kilograms body weight	12 grammes
5–10	¾ gramme	101 grammes	4 milligrams/kilograms body weight	12 grammes
Over 10	1 gramme	135 grammes	4 milligrams/kilograms body weight	12 grammes

Paraplegia—Paraplegia was present in eight of the patients on admission to hospital. This is a high incidence, explained by the fact that it was only the children's inability to walk which persuaded the parents to bring them to hospital. In six cases the paraplegia disappeared completely after costo-transversectomy. In one child (Case 7) there is still some spasticity in one leg, but in this child the operation had to be delayed for six months because of pleurisy, and the spinal lesion amounted to almost total destruction of one vertebral body with subluxation of the one above. In the eighth child (Case 9) the paralysis made no response to costo-transversectomy, but was relieved after laminectomy four months later.

Paraplegia from lesions such as were present in those two cases (Fig. 4) appears to call for a more radical approach, and, since such spines may be unstable, the type of operation introduced by Hodgson and Stock (1956) is probably the best.

FIG. 4

Case 9—A lateral radiograph of the thoracic spine. The eighth thoracic vertebra is almost completely destroyed and the upper part of the column subluxated forwards. The paraplegia in this patient made an unsatisfactory response to costo-transversectomy. A more radical operation is necessary for paraplegia in these circumstances.

DISCUSSION

It seems to be accepted that the spread of the tuberculous infection in the form called spondylitis anterior is direct (Dobson 1956) and due to several factors. The tension in the abscess is itself one of these; it can be demonstrated at operation, and it appears to cause pressure necrosis in the same way as an aortic aneurysm. The pneumo-dynamic effect of respiration may be similar in its action (Ménard 1900, Capener 1954). Loss of blood supply from thrombosis or endarteritis of the vessels serving the vertebral bodies may make matters worse, as may their occlusion or destruction by large dissecting abscesses (Cleveland and Bosworth 1942). All these factors may have their effects lessened by early release of the abscess, the earlier the better. The results obtained in our cases support this view.

Further, if destruction in the anterior parts of adjacent vertebrae is caused mainly or partly by pressure from the abscess combined with the pneumo-dynamic effect of respiration, regeneration of the bodies should be expected if drainage is performed before any real collapse has occurred. I believe that this has been demonstrated in several of our cases (Cases 2, 8, 9, 10 and 11; Figs. 5 to 8). Even if some of the destruction is due to ischaemic necrosis one

FIG. 5

FIG. 6

Case 8. Figure 5—Partial destruction of the ninth and tenth thoracic vertebrae with spondylitis anterior in the sixth, seventh and eighth. Figure 6—The same spine seventeen months later. Spondylitis anterior has disappeared. The sixth, seventh and eighth vertebrae have recovered normal shape, the tenth has become almost normal in outline and regeneration is apparent in the ninth.

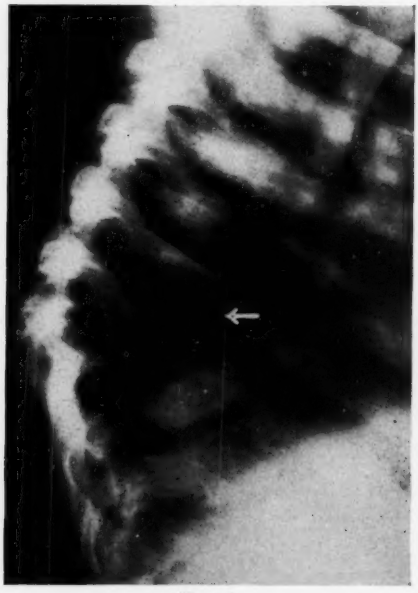


FIG. 7

FIG. 8

Case 11. Figure 7—Total destruction of the ninth thoracic vertebra and sub-total destruction of the eighth. Severe spondylitis anterior in the sixth and seventh. Figure 8—The same spine nine months later. The sixth and seventh vertebrae are restored almost to normal and some reconstruction has taken place in the eighth.

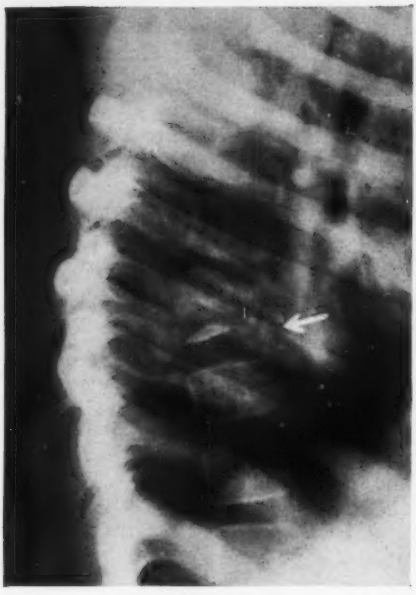


FIG. 9

FIG. 10

Case 13. Figure 9—The seventh thoracic vertebra is represented only by a dense sequestrum. Figure 10—Seven months later the sequestrum is " revascularised " and fused with the remnants of the sixth vertebra.

FIG. 11

FIG. 12

Figure 11—Total destruction of the ninth thoracic vertebra with considerable destruction of the eighth, tenth and eleventh. Figure 12—Three years later, considerable recovery is apparent in the eighth and eleventh, and some recovery is apparent even in the ninth and tenth.

should expect regeneration in the vertebra of a child just as one does in coxa plana, provided that mechanical pressure on the affected vertebrae be avoided. This involves prolonged recumbency. Regeneration of apparently ischaemic bone was shown by Dobson (1956). It can also be seen in Figures 9 and 10 (Case 13).

This possibility of regeneration of necrotic fragments raises a point of operative technique. In children the operation should consist of no more than a conservative costo-transversectomy, with removal only of pus and of spontaneously presenting sequestra. Curettage is to be avoided, for most of the bone which would be removed will regenerate and take its part in the growth of the spine (Figs. 11 and 12).

In Pott's paraplegia of early onset in children, costo-transversectomy may have a wider application than was suggested by Seddon (1956). It is certainly the operation of choice in every early case of thoracic disease in children with an appreciable abscess but without paraplegia. Our conclusions in this respect agree with the view of Griffiths, Seddon and Roaf (1956): "We believe that this operation, enlarged to include the evacuation of accessible necrotic material, should be performed in all cases of thoracic tuberculous caries, with or without paralysis, if the radiographs show a shadow of an abscess and if the disease is recent."

SUMMARY AND CONCLUSIONS

The following preliminary conclusions seem possible.

1. In early cases of Pott's disease of the thoracic spine in children the treatment should include chemotherapy, recumbency and costo-transversectomy. An exception may be made if severe destruction has led to subluxation of the column, when more radical surgery is indicated.
2. Combination of conservative treatment with costo-transversectomy can prevent spread of the disease along the vertebral column, and can lead to regression of this "spondylitis anterior."
3. The abscess can be totally eradicated and the risk of recrudescence therefore diminished.

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HYDATID DISEASE OF THE SPINE

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Symptomless hydatid disease may be discovered incidentally by routine radiological examination. Symptoms, if they occur, are usually caused by pressure on adjacent structures, but occasionally a dramatic onset is associated with the infection or spontaneous rupture of a cyst, particularly in the liver or lung. In the relatively rare instances when the disease affects bone, pressure symptoms and pathological fractures predominate. Radiological examination is usually of value and sometimes diagnostic. With modern freedom of travel the disease may be carried to areas where it is not suspected, and the interpretation of radiographs thus acquires particular importance.

The disease is caused by the ingestion of the ova of the Taenia Echinococcus. The definitive host is usually the dog, which becomes infested by eating offal from an intermediary host harbouring hydatid cysts. In most parts of the world, the intermediary host is commonly the sheep. The scolices within the cysts develop into the mature worms in the intestine of the definitive host. Their ova are then excreted in the faeces. Faecal contamination of food or water may then lead to human infestation. When the ovum enters the intestinal tract of an intermediary host, its envelope is dissolved. The released embryo may migrate through the intestinal wall to enter the portal venous system. The embryos develop into larvae in about three weeks. The larva forms a cyst within which scolices grow and within which also daughter cysts often develop. The host reacts by forming an ectocyst from connective tissue. About 75 per cent of these embryos are trapped in the first filter, provided by the liver, and 15 per cent are caught in the second filter, provided by the lungs (Howorth 1945). The remainder pass these barriers and may settle elsewhere. Cysts developing in soft tissue are spherical and may reach a diameter of several centimetres. Death of the parasite is often followed by calcification of the ectocyst (Jidejian 1953).

BONE INVOLVEMENT

When embryos are deposited in bone, destruction occurs by mechanical pressure without inflammatory reaction. Because of the rigidity of bone tissue, the cyst enlarges unusually slowly, and its shape is often irregular and not spherical as in other tissues. Later, the cortex may be perforated, and relatively exuberant growth then protrudes into the adjacent soft tissues where the usual reaction of ectocyst formation may be observed. Such ectocysts may also, in time, calcify.

Incidence of bone lesions—Howorth (*loc. cit.*), in an extensive review of the literature, concluded that about 1,000 cases with bone involvement had been recorded and that these represented an incidence of about 1 per cent. Out of 1,874 cases of hydatid disease in the Hydatid Registry of the Royal Australasian College of Surgeons, 2·4 per cent involved bone (Woodland 1949).

Site of bone lesions—The commonest site of bone lesions in hydatid disease is usually considered to be the pelvis. Howorth found this to be involved in about 36 per cent of cases. The spine was involved in 18 per cent and the sacrum in 11 per cent. Bellini (1946), Pugh (1951) and Woodland (*loc. cit.*), however, believed that the spine is most often affected—in 50 per cent of all cases according to the first author.

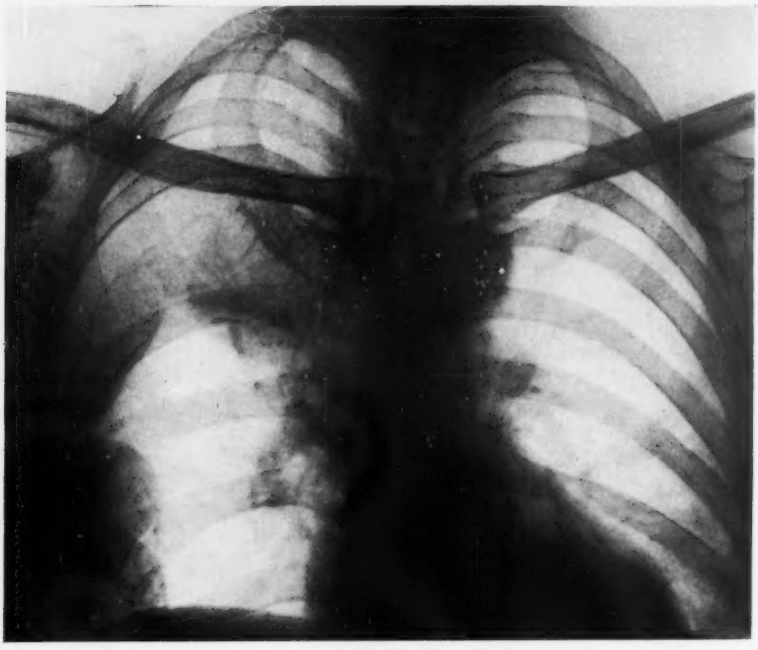

FIG. 1

Case 1—Three large hydatid cysts are present in the right lung. The right sixth rib is expanded throughout most of its length, with cortical thinning and oval areas of translucency.

FIG. 2

FIG. 3

Case 1. Figure 2—The cysts in the lung and the rib lesion are again visible, but the spine appears normal. Figure 3—Seven months later, T.4 vertebra shows partial collapse, and non-specific destructive changes have developed in T.6 and 7 vertebrae.

RADIOLOGICAL CHANGES

The radiological changes in skeletal hydatid disease may be considered in relation to the stage at which they are observed.

Early bone lesions are characterised by ill defined areas of translucency, without sclerotic or periosteal reaction, resembling a bunch of grapes. If observed at this stage, the condition can barely be differentiated from other cystic lesions, such as simple or aneurysmal bone cysts, osteoclastoma, fibrous dysplasia or osseous tuberculous foci.

Developed bone lesions show well defined areas of translucency, which tend to be circular or oval in the long axis of the affected bone. The pattern, however, may be less regular, especially when adjacent daughter cysts are present. The margins are always smooth and show surrounding sclerosis. This sclerosis indicates bone reaction and, although usually attributed to secondary infection, is more likely a simple response to pressure. At this stage the bone may expand, with thinning of the cortex. The cysts having once begun to develop in a bone, with a predilection for a highly vascularised area of spongiosa, tend eventually to spread throughout its length. The stage is now set for a further development, namely rupture of the hydatid tissue through the cortex and the periosteum.

Advanced bone lesions are thus accompanied by a break in the cortex and the development of associated soft-tissue shadows with smooth and rounded margins. Such lesions may attain considerable size and have been described by Bellini (*loc. cit.*) as " ossifluent abscesses."

Lesions in the spine—These deserve special consideration. In the early stages a cystic area may arouse suspicion, in addition to the conditions mentioned above, of a primary or secondary neoplasm, including vertebral angioma. In the late stages, which develop slowly, the areas of translucency in the affected vertebrae are partly masked by reactive sclerosis. " Ossifluent abscesses " may be visible as soft-tissue shadows, and the heads of the adjacent ribs may be involved. In oblique views the laminae may be seen to be affected. This has been stated to tend to exclude tuberculosis. Much more important in this differentiation is that the intervertebral spaces in hydatid disease remain intact and are not narrowed unless secondary infection has developed. That would hardly be expected if such extensive bone involvement were tuberculous. A more difficult differentiation is to be made from a plasmacytoma, in which soft-tissue masses, formed by growth of the tumour through the cortex, may present a very similar appearance. Moreover, this tumour does not provoke a marginal sclerotic reaction. Rounded shadows caused by hydatid cysts in the lungs may dispel doubt, practically excluding myeloma (Hodges, Phemister and Brunschwig 1941). Another differentiating factor is probably the rib involvement, although even in this case the transition to multiple myelomatosis may be suspected.

CLINICAL MATERIAL

This paper reports three cases of spinal involvement, which are the only examples of skeletal hydatid disease encountered at the American University Hospital and the Orient Hospital, Beirut, during two years from October 1954. In each of these cases cord pressure symptoms were prominent. Attention has recently been called to this feature by Mills (1956). The total number of cases of hydatid disease of all types presenting during this period could not be determined accurately because operation in some cases was refused, but is estimated at forty-five. These figures should not be taken to indicate a high incidence of bone lesions, because Jidejian (*loc. cit.*) reported a series of 190 cases from the American University Hospital without skeletal involvement.

CASE REPORTS

Case 1—A man aged thirty-six was admitted in March 1946 with back pain of three years' duration, radiating from just below the angle of the right scapula to the axilla and nipple. Tenderness was found over the right sixth rib, and radiological changes affecting the rib were ascribed to plasmacytoma. Five months later, the patient was readmitted with partial

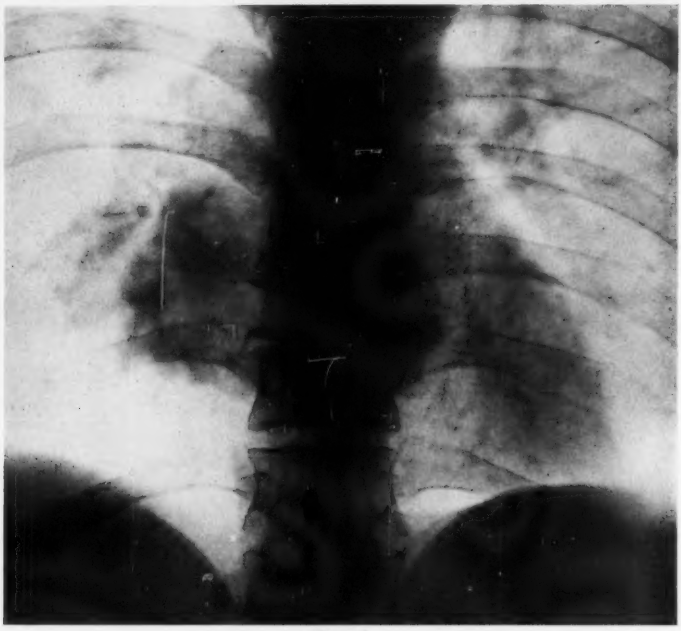

FIG. 4
Case 2—Bilateral paravertebral shadows with smooth, rounded margins at T.9 level. Expansion and destruction of head of right ninth rib. Thinning of right pedicle of T.9.

FIG. 5

FIG. 6

Case 2. Figure 5—Antero-posterior tomograph (6½ centimetres) showing the paravertebral shadows. Figure 6—Antero-posterior tomograph (4 centimetres) showing expansion and destruction of the right ninth rib.

paraplegia. Myelography revealed an incomplete block at the level of T.12 vertebra, becoming complete at T.9. On decompression, hydatid cysts were found in large numbers. Improvement followed, but recurrences necessitated further operations. In November 1955 six hydatid cysts were removed from the fourth thoracic vertebra, with some relief. In June 1957 further cysts were removed from the first thoracic vertebra and the posterior mediastinum. After this operation little function returned to the lower extremities, and later the paralysis became complete below this level.

Review of the radiological findings—Radiological examination of the chest in October 1947 (Figs. 1 and 2) revealed no spinal abnormality, but three large round opacities in the right lung represented hydatid cysts. In addition, the right sixth rib was expanded, with thinning of the cortex by oval and circular areas of translucency. This process involved the whole length of the rib except its anterior end. A further lateral radiograph of the chest, taken after laminectomy and removal of the hydatid cysts in the lung, showed destructive changes in the bodies of T.6 and T.7 vertebrae, and partial collapse of T.4. The disc spaces were well preserved and it seemed likely that these destructive changes represented early manifestations of hydatid disease. The appearance, as indicated above, was not diagnostic at this stage.

Operation was followed by frank osteomyelitis with the development of much deformity and sclerosis, which masked the changes of hydatid disease in subsequent radiographs of the spine.

Comment—This case illustrates early involvement of the thoracic spine. Incidentally, advanced changes were present in the right sixth rib.

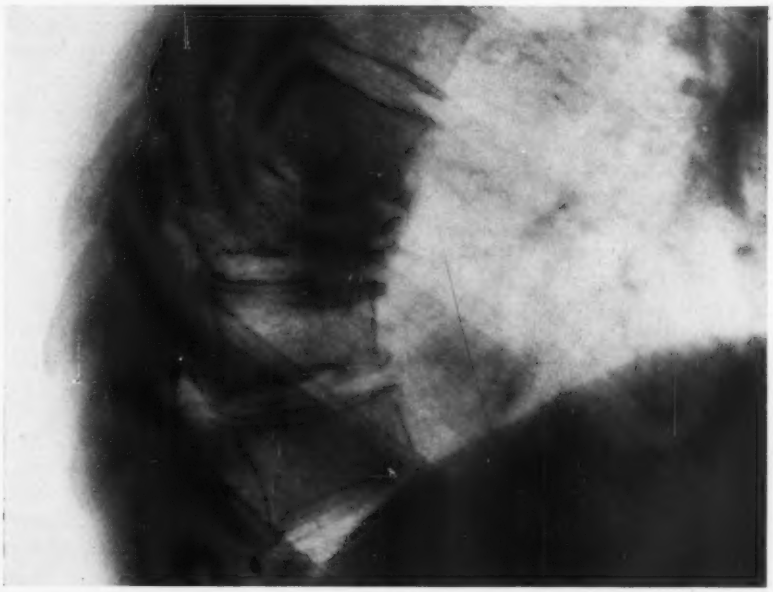

FIG. 7
Case 2—Partial collapse of T.9 vertebra, with some irregular sclerosis within the body. The disc spaces are well preserved.

Case 2—A man aged forty-five, admitted in December 1955, had complained of back pain with progressive numbness and weakness of both lower extremities for one and a half years, and inability to walk for three months. At the same time he noticed kyphosis developing in the thoracic region. For one month before admission he had suffered difficulty in urination

and had become constipated. Examination revealed kyphosis with a bulge of the thoracic vertebrae between T.6 and T.10, without tenderness. Chest examination was negative. The liver was not enlarged and no masses were palpable in the abdomen. Spastic paraplegia, with increased reflexes, was demonstrated. Pain and touch sensations were everywhere intact. Vibration sense as well as the sense of position were equivocal in the lower extremities. The clinical diagnosis was that of a compressive lesion of the spinal cord of undetermined nature. The Casoni test was negative and eosinophilia was not found.

Radiological examination—In the antero-posterior view of the thoracic spine (Fig. 4) paravertebral shadows with smooth rounded margins were evident at the level of T.9 vertebra, that on the right being larger than that on the left. They were more clearly shown in the 6½-centimetre tomograph (Fig. 5), and the 4-centimetre tomograph (Fig. 6) demonstrated destructive changes in the head of the right ninth rib. These had expanded the rib and eroded the cortex. The appearance was very like that in Case 1. The right pedicle of T.9 vertebra had also been eroded. The lateral view (Fig. 7) confirmed that the body of T.9 vertebra was partly collapsed, and some irregular density was visible within it. The disc spaces were well preserved. Myelography revealed an incomplete block at the level of T.12.

After laminectomy the patient made an uneventful recovery, with complete relief of the paresis and disappearance of sensory changes. The reflexes in the lower extremities were still slightly exaggerated. He remained well until last seen in April 1958. Pathological examination of material from the ninth thoracic vertebra and the right ninth rib confirmed the diagnosis of hydatid disease.

Case 3—A woman aged thirty was admitted in June 1956 complaining of recurrent mid-thoracic pain since January 1948, which radiated into her shoulders. Six months before admission she suffered a severe bout of pain in the mid-thoracic region which radiated into both legs. Four months later she noticed difficulty in walking and rapidly became bedridden. On admission she was unable to pass urine and was severely constipated. Paraplegia in flexion, with a complete sensory level at T.5 vertebra, was demonstrated. Clinical examination of the chest and abdomen revealed no abnormality.

Radiological examination of the thoracic spine revealed widely destructive changes in the fourth, fifth and sixth thoracic vertebrae. In the antero-posterior view (Fig. 8) marked erosion of the left sides of these vertebral bodies was evident. The corresponding left pedicles had been destroyed. The posterior part of the left fifth and sixth ribs showed gross destruction and adjacent oval cavities; these indicated intrinsic bone disease in addition to any changes of pressure erosion that might be present. A large circular soft-tissue opacity lay in the left chest, posteriorly and in contact with the bone lesions. The intervertebral disc spaces were intact. In the lateral radiograph (Fig. 9) central areas of destruction were seen within the affected vertebrae. The destruction of the pedicles and the presence of the soft-tissue mass were again demonstrated. This case illustrates the very advanced stage of the disease.

At operation in June 1956 the fifth and sixth left ribs were found to be eroded along a length of about ten centimetres from their necks. Just under the intercostal muscles and in the left costo-vertebral angle a large degenerate hydatid cyst filled with a great number of daughter cysts, was accidentally opened. The area was thoroughly cleaned. During this procedure small daughter cysts were seen to extrude through small holes in the lateral aspect of the body of T.5 vertebra. The dura was seen from its lateral aspect because the pedicle had been completely eroded. No significant improvement followed the operation, and, after discharge from hospital, the patient failed to return for follow-up examination.

DISCUSSION

The radiological findings in this disease can be mistaken for a number of other conditions, most important among them malignant disease of bone. In Case 1 the diagnosis was known

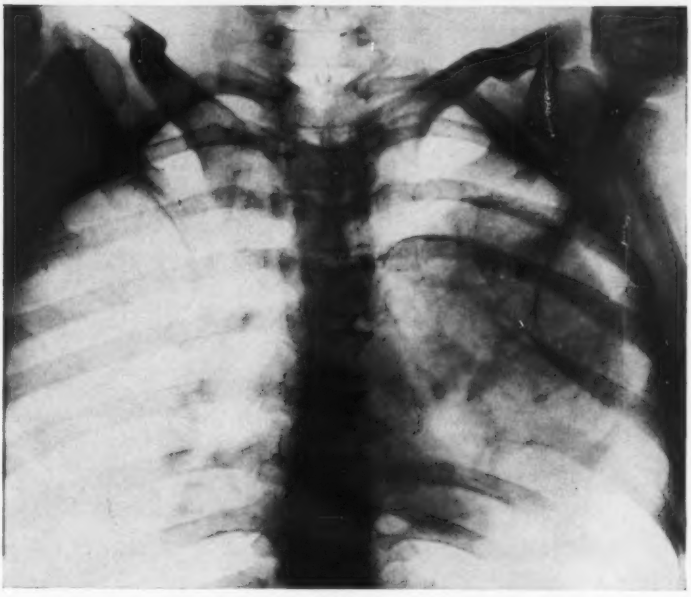

FIG. 8

Case 3—The pedicles and the left sides of the bodies of T.4, T.5 and T.6 vertebrae have been eroded, together with the posterior parts of the left fifth and sixth ribs. In association with these changes, a large circular soft-tissue mass is present in the left hemithorax. The disc spaces are intact.

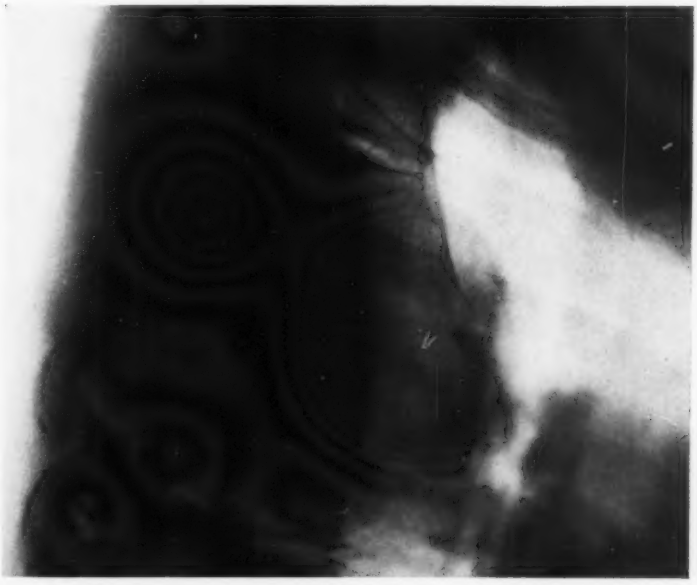

FIG. 9

Case 3—Central areas of destruction are visible in affected bodies. The erosion of the pedicles and the soft-tissue mass is again shown.

when we first saw the patient. In Case 2 one of us favoured hydatid disease; the other a plasmacytoma progressing to multiple myelomatosis. He was influenced by the presence of myelographic blockage well below the site of the bone lesion, suggesting the presence of tumour tissue within the neural canal. This was, in fact, caused by the presence of numerous hydatid cysts. In Case 3 hydatid disease and neurofibroma were considered possible, but we both favoured the former. In the advanced stage it is less difficult to make a correct diagnosis, but, in two of these cases, malignant disease was seriously considered. The greatest difficulty arises in early disease. Nevertheless it is important that a correct pre-operative diagnosis be made because treatment depends upon it, and ill advised biopsy may rupture the cysts, with consequent recurrences. The differential diagnosis will rest on positive Casoni or positive Weinberg tests, but these are often falsely negative. Eosinophilia may give an indication of the disease, but is a common finding in intestinal infestations. A chest radiograph showing rounded globular shadows in the lung, together with involvement of the vertebrae, may suggest multiple metastases, and the patient might be left to become paralysed on the assumption that the condition was inoperable. In metastatic carcinoma adjacent vertebral bodies are not usually affected, and costal lesions affect only part of a rib, which is not often expanded. The presence of soft-tissue shadows besides a destructive vertebral lesion, with intact disc spaces, should bring this condition into the differential diagnosis.

SUMMARY

1. The radiological features of skeletal hydatid disease are discussed. Osseous lesions occur in about 1 to 2 per cent of cases, bone being involved only after the embryos have passed the filters provided firstly by the liver and secondly by the lungs. At first, ill defined areas of translucency appear which are not diagnostic. In developed lesions, clear-cut destructive areas, with a surrounding sclerotic reaction, become visible. The cysts thin and expand the cortex and tend to spread throughout an affected bone. In advanced stages the cortex is ruptured, and exuberant hydatid cyst growth takes place in the adjacent soft tissue. Around this an ectocyst forms, which may later calcify, indicating death of the parasite. The progress of the disease is very slow.

2. Three cases of affection of the thoracic spine are described, and the differential diagnosis is considered, particularly from plasmacytoma and neurofibroma. Each case presented with cord pressure symptoms. Operative decompression relieved these totally in one case, incompletely in another, and not at all in the third and most advanced case.

3. With rapid and easy travel in the modern world hydatid disease is liable to be seen in areas where it is not endemic.

We should like to thank Mr H. Jackson Burrows for his helpful advice, and Mr R. J. Whitley, F.R.P.S., Chief Photographer to the Institute of Orthopaedics, Royal National Orthopaedic Hospital, for preparing the illustrations.

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A METHOD OF FOREFOOT RECONSTRUCTION

ALAN W. FOWLER, BRIDGEND, WALES

The operation to be described is designed for the treatment of the severest claw toe deformity when it is impossible to restore the normal anatomy of the metatarso-phalangeal joints, and when there is severe pain under the prominent metatarsal heads. The operation is not intended to replace any of the established conservative operations for claw toes such as tenotomy, tendon transfer, capsulotomy, arthrodesis of the interphalangeal joints and proximal phalangectomy.

Etiology—Twelve of the twenty patients with irreversible clawing described here suffered from the destructive effects of rheumatoid arthritis. The remaining patients had claw toes associated with hallux valgus or pes cavus, in whom prolonged fixed deformity had caused disorganisation of the metatarso-phalangeal joints.

Morbid anatomy—The toes are drawn on to the dorsum of the foot and the metatarsal heads are prominent in the sole. This prominence is partly due to the piston-like action of the proximal phalanges which depress the metatarsal heads (Fig. 1). However, it is a mistake to assume that the metatarsal heads will be restored to their normal position when toe pressure is eliminated, whether by amputation of the toes (Fig. 2) or by the provision of adequate toe room in the shoes.

FIG. 1

Figure 1—Diagram showing the mechanism by which the proximal phalanges depress the heads of the metatarsals into the sole of the foot. The metatarsal weight-bearing pad is drawn forwards and lies in front of the metatarsal heads. Figure 2—Amputation of the toes has not relieved pressure on the metatarsal heads in this foot.

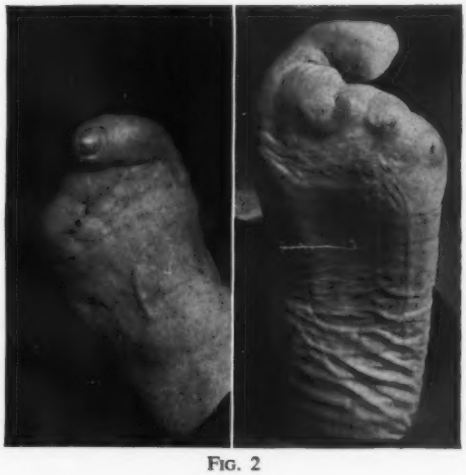

FIG. 2

The prominence of the metatarsal heads is also increased because the weight-bearing pad is drawn forwards away from the underside of the metatarsal heads (Fig. 1). In rheumatoid arthritis synovial cystic formations beneath the affected joints may also be a cause of pain.

The longer metatarsals are relatively more prominent when the foot is in a shoe with a moderate or high heel and when the foot is raised to the " take off " position (Fig. 3). For this reason callosities are more likely to occur beneath the heads of the second, third and fourth metatarsals, especially when the discrepancy is increased by a short first metatarsal.

TECHNIQUE OF OPERATION

A tourniquet is used unless there is evidence of a poor circulation. A dorsal transverse incision is made just proximal to the webs of the toes. The ends of the incision curve back

for a short distance along the shafts of the first and fifth metatarsals (Fig. 4). The skin, veins, extensor tendons and fat are divided and reflected in one layer to expose the metatarso-phalangeal joints. The proximal halves of the proximal phalanges are removed, care being taken not to injure the flexor tendons.

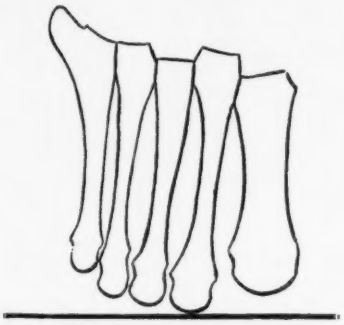

FIG. 3

The extra length of the second, third and fourth metatarsals renders them more prominent when the foot is in a shoe with a raised heel and when the foot is in the " take off " position.

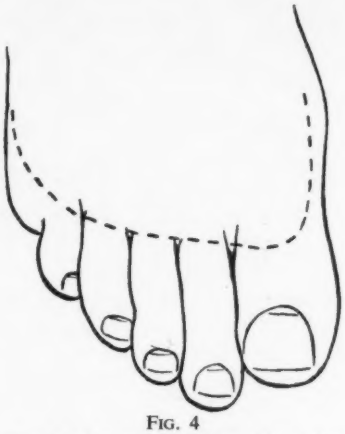

FIG. 4

The incision which divides skin, veins and extensor tendons.

The metatarsal heads are now exposed and their alignment can be determined (Fig. 5). For reasons stated above it is important to reduce the length of the longer metatarsals so as to straighten the convex anterior line of the metatarsal heads (Fig. 6). The under surfaces of the metatarsal heads are trimmed so as to form an even weight-bearing area. At the least, the condylar projections are removed, but it is usually necessary to remove more than this from some heads in order to bring all the metatarsals to the same level (Fig. 7). In severe cases it may be necessary to excise the whole of the metatarsal heads, and further shortening of the metatarsals may be required in pes cavus. In reshaping these bones it is important to bear in mind that the weight-bearing surface will not lie parallel with the shaft of the metatarsal but at a variable angle depending on the height of the longitudinal arch and of the heel of the shoe (Fig. 8).

FIG. 5

The exposure of the metatarsal heads after excision of the proximal halves of the proximal phalanges.

Usually the sesamoids will retract when the base of the proximal phalanx is removed, thus reducing the relative prominence of the first metatarsal, unless they are adherent, when they must be excised.

The skin alone is sutured, and the toes return to their deformed position with the metatarsal weight-bearing pad still displaced forwards (Figs. 8 and 9). To correct this deformity an ellipse of skin is removed from the plantar surface of the foot behind the

metatarsal heads. Enough skin is removed so that when the wound is sutured the metatarsal pad is replaced beneath the remodelled metatarsal heads (Figs. 10 and 11). It must be emphasised that only the thickness of the skin is removed, as in taking a Wolfe graft.

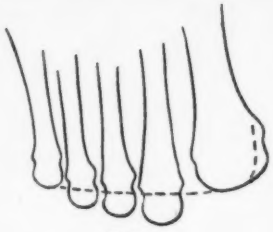

FIG. 6

FIG. 6

Trimming the metatarsal heads. The longer metatarsals are shortened so that the convex anterior line of the metatarsals is straightened.

FIG. 7

Sufficient bone is removed from the plantar surfaces to produce a uniform weight-bearing surface.

FIG. 7

A pressure dressing is applied; no plaster fixation is used because swelling after operation is considerable. After two to three weeks the sutures are removed and the toes are then carefully aligned in a plaster toe cap (Fig. 12). This is worn for four weeks and the patient is encouraged to walk. After removal of plaster an insole incorporating a metatarsal bar is worn in a low-heeled shoe.

FIG. 8

FIG. 9

FIG. 10

FIG. 11

Figures 8 to 11—Diagrams showing how the metatarsal weight-bearing pad is replaced beneath the remodelled metatarsal heads by removing an ellipse of skin from behind the metatarsal heads.

This operation can be modified to suit any particular patient; thus, if the toes are not severely deformed the removal of bone can be limited to the metatarsal heads and the excision of sole skin can be omitted. On the other hand if the deformity at the proximal interphalangeal

joints is severe it may be necessary to excise more than half of the proximal phalanges. If the alignment of the toes is satisfactory plaster fixation is not always necessary but it does help to control swelling during early walking.

RESULTS

This paper reports the results of forefoot reconstruction on the first twenty patients, fifteen of whom had the operation on both feet. The follow-up period varies from one to four and a half years, the average being two years three months. All patients expressed gratitude for gaining great relief from pain and for a new lease of activity (Figs. 13 to 16).

When re-examined, seven patients were found to have one or more small plantar callosities but these were either painless or caused little discomfort. The first patient operated on was an exception; she required further operation on both feet in order to trim away more bone. Exposure of the metatarsal heads through the old incision was accomplished without difficulty.

The recurrent callosities did not appear until more than six months after operation, and all occurred in patients who had not been supplied after operation with metatarsal supports. This is the reason why a metatarsal support is prescribed even though most do not feel the need for it. The remodelled heads cannot be as efficient as the normal and it is therefore reasonable to continue with efforts to relieve pressure from them.

FIG. 12
A plaster toe cap may be worn during the first few weeks of walking.

In the early operations the metatarsal heads were trimmed too sparingly; with increasing experience more bone has been removed. One patient, however, illustrated a possible disadvantage of removing the whole of all the metatarsal heads. This was a woman who had had some difficulty in her balance. After the operation she felt more unsteady and tended to fall forwards, possibly because of the shortening of the foot.

In one patient the return of circulation after release of the tourniquet was sluggish and the edge of the proximal flap died. This patient had atrophic tissues and a tourniquet should not have been used. The skin on the dorsum of the foot has an inferior blood supply; so the proximal flap should be dissected as little as possible.

In one patient the sutures were removed on the tenth day and the wounds gaped. The sutures should be retained for two weeks on the dorsum of the foot, and up to three weeks on the sole.

DISCUSSION

This is a preliminary communication. Final appraisal of this operation can be possible only after ten or twenty years of " wear " on the feet. But, if the operaton is reserved for severe deformities, it is unlikely to do harm and the relief will probably be permanent. Forefoot reconstruction should be a last resort—a salvage operation when other measures have failed to give relief. The operation does not always eliminate the need for surgical shoes, especially in those patients with feet deformed by rheumatoid arthritis.

It is usually recommended that if a patient with irreversible clawing of the toes cannot be made comfortable in surgical shoes then the last resort is amputation of all the toes and remodelling of the metatarsal heads (Nissen 1957). Provided the metatarsal heads are trimmed,

amputation gives good results, but forefoot reconstruction has two advantages. Firstly, the metatarsal weight-bearing pad is replaced, whereas after amputation of the toes it is drawn farther away on to the dorsum of the foot. Secondly, the cosmetic result is more acceptable;

FIG. 13

FIG. 14

Figure 13—The feet of a woman aged fifty-one with rheumatoid arthritis. Figure 14—The appearance sixteen months after operation.

patients will readily agree to have their toes straightened but they are reluctant to have them removed.

It is freely admitted that the toes have little active function after forefoot reconstruction, but they are not entirely useless because, being partly flail, they readily conform to, and fill up, the empty space at the front of the shoe. In this respect the toes resemble the hallux after a

successful Keller's operation with the hallux assuming the valgus position necessitated by most types of footwear. In spite of this the bunion does not recur because the metatarsal head, in addition to being trimmed, is disconnected from the proximal phalanx which can

FIG. 15

FIG. 16

Figure 15—The right foot of a woman aged fifty-four with rheumatoid arthritis. Figure 16—The appearance twenty months after operation.

no longer impart a medial thrust to the metatarsal head. Forefoot reconstruction involves a similar procedure on all the toes, providing relief from pressure by the removal of prominent bone and the disconnection of the proximal phalanges from the metatarsal heads.

The dorsal transverse approach has several advantages. It divides no important structures, provides easy access to the metatarsal heads, is repaired by skin sutures only, and leaves an inconspicuous scar. Two other approaches to the metatarsal heads have been described. Hoffmann (1912) advocated resection of the metatarsal heads through a transverse plantar incision behind the webs of the toes. With this approach there is a possibility of damage to the neurovascular bundles and flexor tendons. Another disadvantage of Hoffmann's operation is that failure to remove any of the proximal phalanx calls for wider excision of the metatarsal in order to correct the dorsal displacement of the toes.

Larmon (1951) described an approach using three separate incisions. A Keller's operation is done on the hallux, and the other metatarsal heads are reached through two dorsal longitudinal incisions in the webs between the second and third and the fourth and fifth toes. This is a difficult approach because of the limited space and the depth of the metatarsal heads. Another disadvantage is that because the metatarsal heads are not all exposed in the same wound their relative prominence cannot be determined and therefore it is difficult to decide how much bone to remove.

Finally, mention should be made of two operations designed to relieve prominent metatarsal heads without removing bone from them. McKeever (1952) described a metatarsal shortening operation for the treatment of plantar callosities. The necks of one or more metatarsals are divided and the heads replaced after shortening the shafts. Broomhead (1955) described a metatarsal rotation operation which he has used in the treatment of up to three prominent metatarsal heads. The offending metatarsal is divided half an inch from its base, the shaft is then resected subperiosteally and rotated through 180 degrees. Both these operations must be difficult especially in rheumatoid feet with fragile bone. Moreover, in many such patients the metatarsal heads are eroded and unsuitable for conservative surgery.

SUMMARY

1. An operation is described for the relief of irreversible claw toes associated with prominent and painful metatarsal heads.
2. The operation is suggested as an alternative to amputation of the toes.
3. The results of the operation done on twenty patients who have been followed up for a year or longer are reported.

I wish to thank Mr J. G. H. James, Mr H. J. Richards and Mr J. N. Wilson for allowing me to operate on their patients. I am grateful to Mr A. L. Eyre-Brook and Mr J. G. H. James for helpful criticism.

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BILATERAL HEREDITARY MICRO-EPIPHYSIAL DYSPLASIA OF THE HIPS

L. ELSBACH, DELFT, HOLLAND

Examining an eight-year-old boy who for four years had been suffering from pain in his knees, I found restriction of abduction and medial rotation at both hips. He was small for his age (Fig. 2) and intelligent. The other joints and spinal column appeared normal. Radiographs of the hips (Figs. 3 and 4) showed remarkably small epiphyses. The joint space was widened and the joint line intact. There was no fragmentation of the epiphyses, nor was there any abnormality of the acetabula. Radiographs of the shoulder showed delayed fusion of the nuclei of the upper epiphyses of the humerus (Fig. 5), and the same applied to the nuclei of the carpus (Fig. 6). I knew that the sixty-seven-year-old grandmother of the boy suffered from osteoarthritis of both hips. The radiographs (Fig. 8) showed, in addition to the classical features of osteoarthritis, an obvious flattening of the head, and a prominent spur supero-laterally. When the boy's mother—daughter of the woman just mentioned—was questioned, hip complaints came to light and these were confirmed objectively when it was found that abduction and medial rotation were restricted. The radiographs (Fig. 9) again showed the remarkably flattened head with the supero-lateral spur formation. Like her mother, this woman was small but well proportioned. There were no anomalies of the other joints. She had four children, of whom the two daughters had no complaints, but the two sons, eight and five years old, did show changes. The younger brother gave the same radiographic picture as the elder brother described above: a small epiphysis of a homogeneous structure with an intact joint line (Fig. 7).

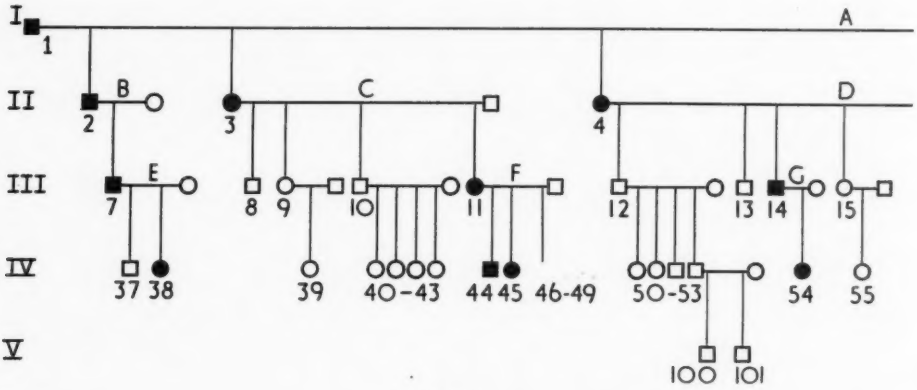

FIG. 1
Family tree. Affected members shown in solid black.

There was now reason enough to examine the whole family, and the family tree is shown in Figure 1. From this it appears that the disease is transmitted as a dominant; that is to say, approximately 50 per cent of the children of a diseased parent are affected and that a healthy parent has no child with this disease.

The man who brought the disease into his family had two sisters who did not have the disease, as none of their issue was affected. Nothing is known about his parents. In all he

produced thirty-eight descendants of the first degree, all carriers of the autosomal dominant gene, of whom seventeen had the disease (45 per cent). Of these there were six male and eleven female carriers.

TABLE I

INCIDENCE OF AFFECTED OFFSPRING IN TEN FAMILIES

Family	With anomalies	Healthy	Total
A	3	2	5
B	1	—	1
C	1	3	4
D	4	6	10
E	1	1	2
F	2	4	6
G	1	—	1
H	2	1	3
I	2	2	4
J	—	1	1
Total	17	20	37

The second generation numbers five descendants, of whom three had certain anomalies (Figs. 8 and 10) and one had osteoarthritis of both hips, but of a different kind (Fig. 11). She was not included in the total of those affected. Her children could not be examined. Inquiry showed that they had no hip or knee complaints. This patient is very important from a viewpoint of heredity.

The third generation has fifteen members, of whom six were certainly affected (Figs. 9 and 12) and one (dead) probably affected. The latter was not included.

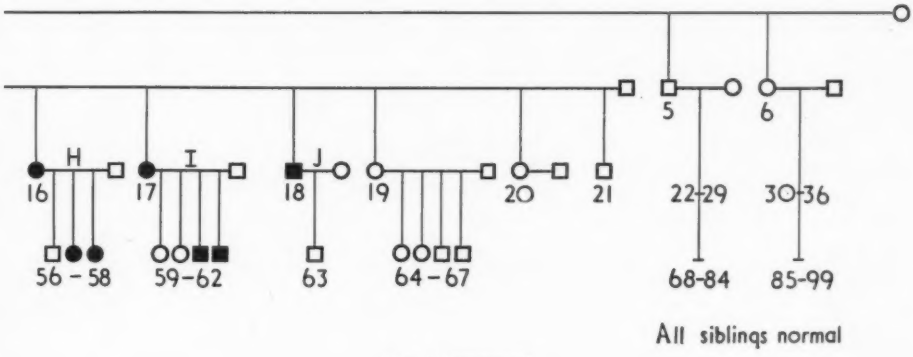

FIG. 1 (*continued*)

The fourth generation consists of seventeen first degree descendants, of whom eight are certainly affected (Figs. 2 to 7, and 13 and 14).

Nearly all the members of the Delft family have only hip anomalies. There are two men who suffer from knee complaints and show dysplasia of the femoral condyles.

There are no anomalies of the spinal column. The children examined show that the epiphysial nuclei of the carpus are late in appearing, and pseudo-epiphyses are visible on the

distal ends of the first phalanges. The adults do not possess the short, plump hands that characterise dysplasia epiphysialis multiplex.

One may thus assume that this hereditary hip disease constitutes a generalised epiphysial growth disturbance, in which the epiphyses about the hip joints are the most seriously affected.

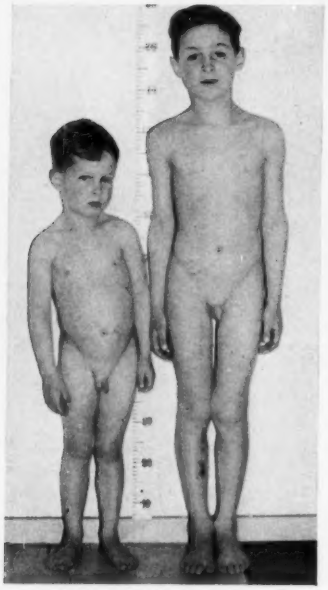

FIG. 2
Photograph of W. R. (*right*) and his brother, L. R.

CHARACTERISTICS OF EPIPHYSIAL GROWTH DISTURBANCES OF THE DELFT FAMILY

The characteristic features of the epiphysial disturbance in the Delft family may be summarised as follows: 1) Transmitted as a dominant hereditary factor with great penetrance. 2) Symmetrical distribution on the two sides. 3) Affection of the epiphyses, especially of the hips. 4) Onset at the age of four at the latest. 5) Metaphysis, neck and diaphysis and acetabula are not involved. 6) The upper epiphyses of the femur of the children are reduced in depth and show a homogeneous, coarse structure without necrosis or fragmentation. There are no marginal erosions. 7) There is no dwarfism, but the patient is short, especially in the lower limbs. 8) The unaffected members of the family are of normal stature. 9) The shape of the hands is normal. 10) The epiphysial nuclei at the upper end of the humerus fuse late. 11) The ankles are not affected. 12) Intelligence is normal. 13) There are no endocrine or metabolic disturbances.

Radiographic changes in the various generations—The radiographs of affected members of the second generation (three patients) show severe osteoarthritis of the hips, with flattening of the femoral heads and supero-lateral beaks and cyst formation. The femoral neck is shortened but there is no coxa vara. One member of this generation has osteoarthritis of the hips of a different type, and is not included in the series. Radiographs of the third generation show six members with the same flattening of the femoral head and supero-lateral beaks and cysts as in the older patients. The femoral neck is shortened but there is no coxa vara. The joint space is hardly or not at all diminished.

The radiographs of the fourth generation differed according to the age of the subject. In one child of five and in four children of eight a small epiphysis of more or less homogeneous coarse structure was seen, without marginal erosions and without zones of sclerosis, rarefaction or fragmentation. The contours of the epiphysis are regular. The metaphysis does not show rarefaction where it borders the epiphysis. The joint space is wide. There is no anomaly of the acetabulum, and no coxa vara.

The epiphysial nuclei of the upper end of the humerus and in the hand are delayed in their development (Figs. 5 and 6). Two children of the fourth generation—one aged eleven and the other aged thirteen—present a different radiographic picture that reminds one of that of the parents (third generation), in that the head is slightly flattened, with supero-lateral protuberances, but wide joint space (Fig. 14). There is no anomaly of neck or acetabulum.

DIFFERENTIAL DIAGNOSIS

Several hereditary epiphysial disturbances of the hip have been recorded. Jéquier and Fredenhagen (1948) and Hamsa and Campbell (1953) described familial cases of osteochondritis juvenilis (Perthes' disease). The radiographs from my cases differ from those of Perthes'

disease. Moreover, only exceptionally has Perthes' disease been located elsewhere than in the hips, and seldom if ever are both hips affected at the same time, so that the symmetrical appearance that I have described does not occur. Despite the longer duration of the complaints,

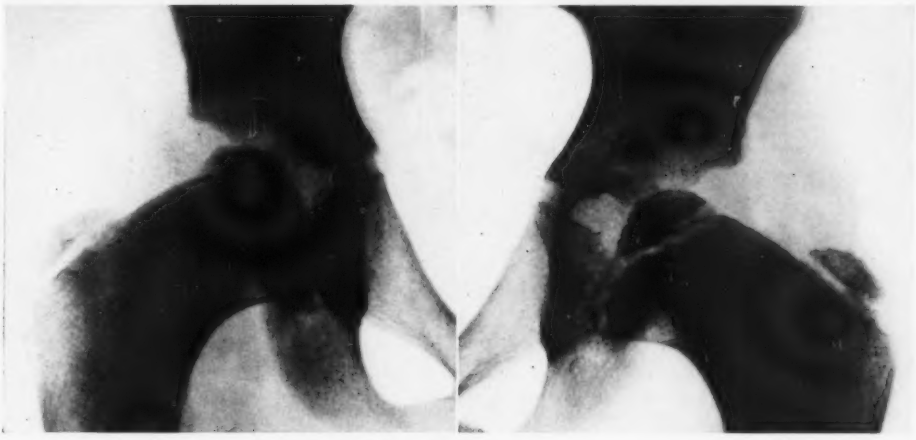

FIG. 3

Right and left hips of W. R., the first patient seen, aged eight years (61 in Figure 1). Note the small epiphyses

FIG. 4 FIG. 5

W. R. Figure 4—Arthrograph of right hip. Figure 5—Right shoulder.

the typical Perthes' syndrome was not found in any of the five younger children. It is possible that in the bilateral familial case of "Perthes' disease" the cause may be found in an epiphysial growth disturbance of a rather serious character (serious because there is an evident necrosis) and may thus be comparable with the other familial epiphysial growth disturbances.

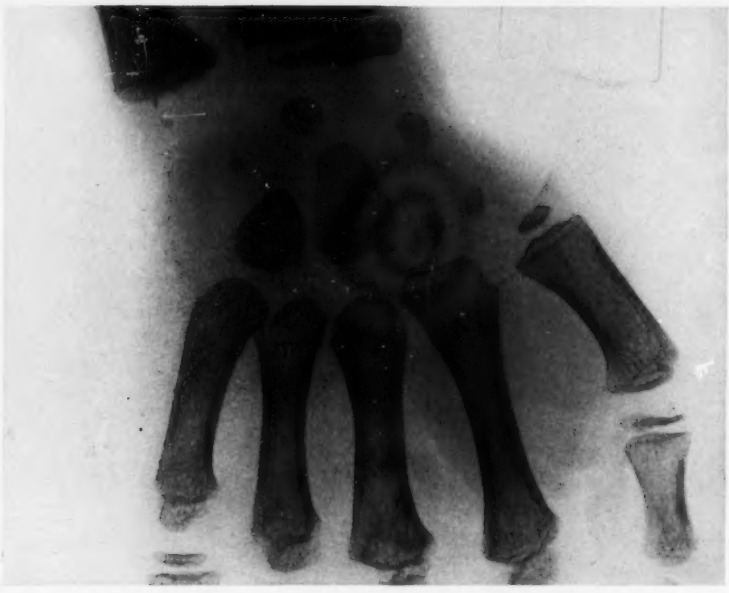

FIG. 6
Left carpus of patient W. R.

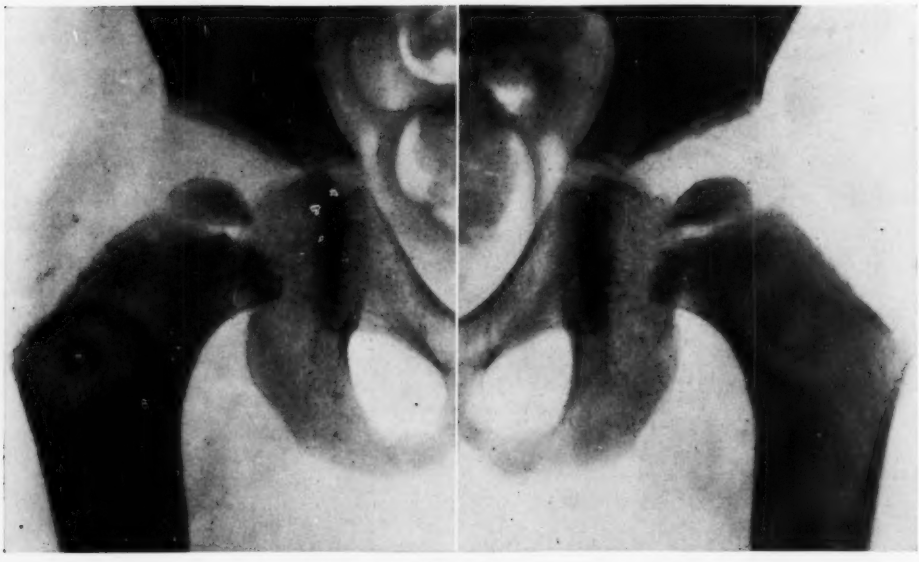

FIG. 7
Right and left hips of L. R., the brother of W. R. (62 in Figure 1). The epiphyses are small.

Dysplasia epiphysialis multiplex—Fairbank described dysplasia epiphysialis multiplex in 1935. In some cases the disease was familial. Characteristics are stunted growth and short fingers with stumpy ends. Radiographically, the epiphyses are irregular in density and contour. Separate ossification centres often occur, so that there is some stippling on the periphery, but never so

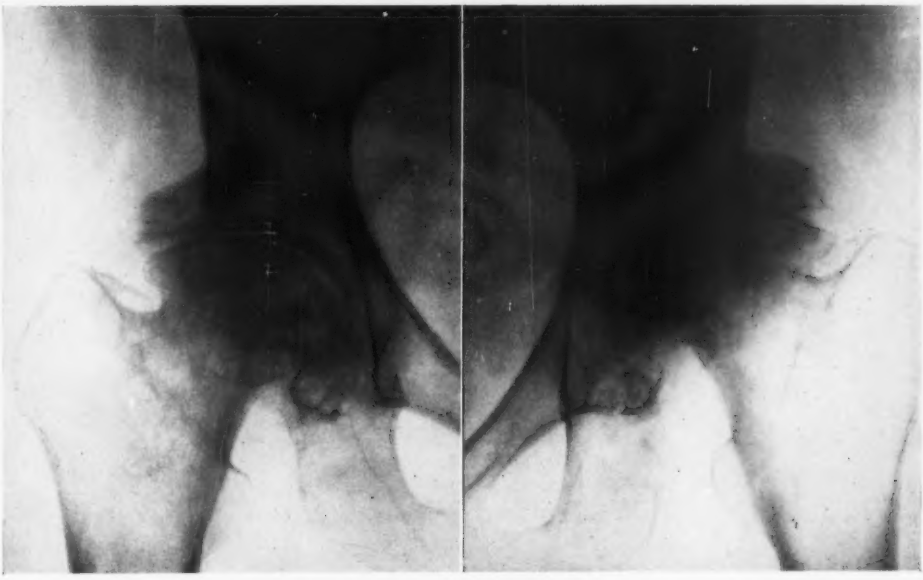

FIG. 8

Right and left hips of the grandmother of patients W. R. and L. R. (4 in Figure 1). Note the flattening of the femoral heads and supero-lateral spur formation.

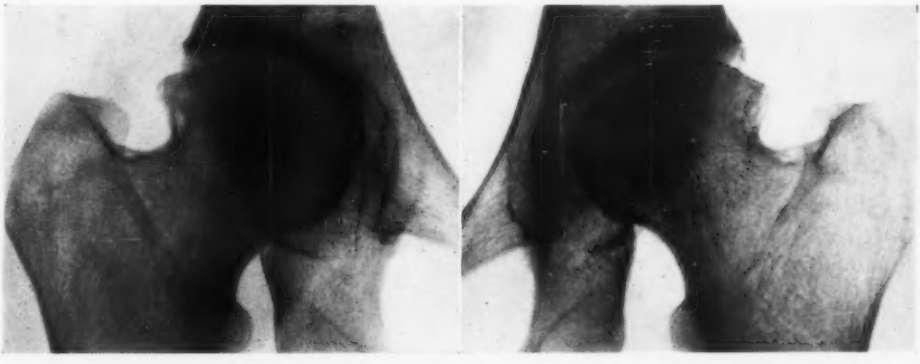

FIG. 9

Right and left hips of the mother of patients W. R. and L. R. (17 in Figure 1). The femoral heads are again flattened and show marked supero-lateral spurs.

much as in dysplasia punctata. Hips, shoulders and ankles are especially affected. As described by Fairbank the disease differs from the picture of the Delft family.

Morquio-Brailsford's disease—In Morquio-Brailsford's disease epiphysial dystrophy is found with typical changes in the spinal column and in most centres of ossification, especially of

FIG. 10
Left hip of another affected member of the second generation—a man aged sixty-two (2 in Figure 1; brother of the patient referred to in Figure 8).

FIG. 11
An unaffected member of the second generation (6 in Figure 1). There is osteoarthritis of a different kind.

the hip. Here too, the acetabula are typically enlarged and irregular. I regard these lesions as an epiphysial reaction to weight bearing, with consequent disturbance of epiphysial growth.

Ribbing's disease—In this disease, which is inherited recessively, the affected members of the family are physically well developed, in contrast with those of the Delft family. Radiographically there is a clear relationship with osseous avascular necrosis, which was lacking in my cases.

Cretinism—Cretinism is characterised by dwarfism and infantilism. In the hips both the early changes and the final deformity may be indistinguishable from those of Perthes' disease.

FIG. 12

Left hip of an affected member of the third generation (cousin of the patient referred to in Figure 9).

COMMENT

It seems that in the cases that I have described the epiphyses are too small and are unable to meet the demands of daily life. In so far as this is to be judged radiologically we only see with advancing age a widening and flattening of the epiphyses, with beak formation. This adaptation proves to be inadequate, as indicated by the occurrence of early osteoarthritic changes in these deformed heads.

In the upper extremities the small size of the epiphyses is of little importance, except perhaps in those who regularly perform hard manual work. In the lower extremities, however, the small epiphyses are clearly not equal to the demands of weight bearing.

The wear and tear of daily life affected the epiphyses in my patients without causing necrosis; and ossification did not occur from multiple centres as in Fairbank's disease and in dysplasia epiphysialis punctata. One may imagine that, when the functional stability of the hips is seriously disordered, the daily burden, which in this case becomes excessive, gives rise to a picture like that of Perthes' disease, with necrosis and its sequelae. In the Delft cases the stability of the hips is still sufficient to prevent necrosis, but not the flattening.

Many examples are known in which the capital epiphyses have been damaged by injury, infection, avascular necrosis or epiphysiolysis, and in consequence have been unable to stand up to the daily wear and tear, and the same may happen in cases of subluxation with incongruity of the femoral head and acetabulum. The congenital hereditary or non-hereditary deformities of the hip epiphyses may act in a similar way. Such a picture is worst in Morquio's disease. When the deficiency is less severe the appearance may be that of Perthes' disease,

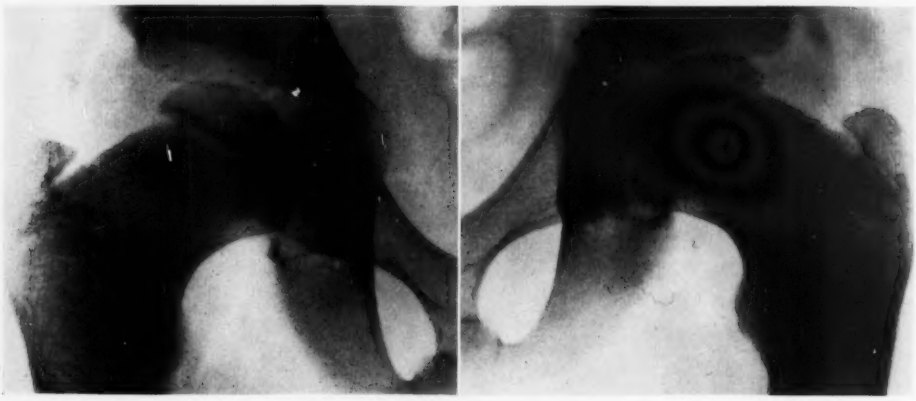

FIG. 13
Another affected member of the fourth generation (second cousin of patients W. R. and L. R. (Figs. 1 to 7)).

FIG. 14
Another affected member of the fourth generation.

which, when both hips are affected, I regard as an epiphysial growth disturbance with necrosis, like Fairbank's disease and Ribbing's disease.

The Delft cases belong to this type, but the epiphysial affection is less serious: fragmentation of the femoral head does not occur and the joint line is intact. Considered in this way, Perthes' disease represents a more serious reaction than the changes found in the Delft family. In Morquio's disease the epiphyses are so severely affected that the hip becomes unstable: thus the picture is again different, and it must be regarded as the most serious reaction. The

epiphysial growth disturbances give radiographic appearances that depend on the seriousness of the affection of the epiphyses and the action of gravity. The ultimate result is the same with all these disorders—namely incongruity of the joint planes with accelerated degeneration of the cartilage.

SUMMARY

1. A family is described of which several members in four generations suffered epiphysial growth disturbances of an unusual kind in the capital epiphyses of the femur, with shortness of stature.

2. This disorder forms one of a group of epiphysial growth disturbances which embraces several recognised disorders, whose effects on the epiphyses vary in severity. They may occur sporadically or they may be inherited as recessive or dominant characters.

3. Differentiation depends on the behaviour of the joint line—in other words, whether the epiphysis starts to show defects through inability to sustain the stress of weight bearing. In the most serious cases the picture is that of Morquio-Brailsford's disease; when the changes are less severe the appearance may be that of bilateral Perthes' disease. Differential diagnosis is no longer possible in later life, because the ultimate condition of the defective femoral heads is the same. Only in the hereditary cases is one able, by studying the capital epiphyses of the hip in childhood, to differentiate between the changes like those of Perthes' disease on the one hand, and micro-epiphysial dysplasia without necrosis on the other.

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COMPRESSION ARTHRODESIS OF THE ANKLE

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Many methods of arthrodesis of the ankle have been described (Kimberley 1936, Speed and Boyd 1936, Watson-Jones 1940, Brittain 1942, Horwitz 1942, Adams 1948) but few clinical studies of any one method have been published. Adams (1948) reviewed the results of thirty arthrodeses by the transfibular approach; in twenty-eight fusion occurred in an average time of thirteen weeks. No further details were given. Barr and Record (1953) reviewed the results of arthrodesis of fifty-five ankles in fifty patients. Two longitudinal incisions were employed and a graft cut from the tibia was placed across the joint line. In eighteen out of twenty ankles arthrodesed for the effects of poliomyelitis, the results were classified as satisfactory. Hallock (1945) studied the results of arthrodesis of the ankle for "old painful fractures" in thirty-nine patients; thirty obtained bony fusion.

This paper presents an analysis of the results of compression arthrodesis of the ankle by the technique described by Charnley (1951, 1953), which requires a transverse incision with division of the extensor tendons. This exposure has evoked adverse criticism: special attention has, therefore, been given in this paper to the possible disadvantages of the incision. The incidence of bony fusion, and the best position for arthrodesis, have also been studied.

CLINICAL MATERIAL

The material for this study is based on fifty-nine operations, of which four were bilateral, in fifty-five patients treated at the Manchester Royal Infirmary, Park Hospital, Davyhulme, or Wrightington Hospital. With minor variations, the same technique has been employed in all operations, which in forty-seven patients were carried out by Mr John Charnley and in the rest by colleagues or assistants. All patients who could be traced were examined by the author, who acted as an independent assessor, and no selection was employed. The shortest

TABLE I

AGE AT THE TIME OF ARTHRODESIS OF THE ANKLE
(Fifty-five patients)

Age at operation	Number of patients
Under 18 years	4
18–60 years	46
Over 60 years	5

period of observation after operation was one year, and the longest nine years. The age of the patients at the time of operation is shown in Table I. It will be seen that most operations were performed in patients of middle age.

The conditions for which arthrodesis was performed are shown in Table II. Of the twenty-one ankles with osteoarthritis, sixteen had sustained fractures with malunion. Five operations were performed for recurrent foot deformity after subtalar-midtarsal fusion after poliomyelitis. Five were performed for gross equinus deformity in spastic hemiplegia. The six miscellaneous cases included one bilateral fusion in myotonia congenita, one spina bifida

with persistent foot drop, one paralytic talipes equinus of obscure origin following a fractured femur, and two Charcot joints.

The details of the operation and post-operative management have been described elsewhere (Charnley 1951, 1953). In the first four patients in this series, while the technique was being

TABLE II

CONDITIONS FOR WHICH ARTHRODESIS WAS PERFORMED
(Fifty-nine ankles)

Osteoarthritis	21
Tuberculosis	12
Poliomyelitis	7
Spastic hemiplegia	7
Club foot	3
Chronic arthritis	3
Miscellaneous	6

developed, a longitudinal approach to the ankle was employed, but in the rest a transverse incision was used. The compression apparatus was left in position for four weeks in fifty of the fifty-nine cases. The total period of immobilisation is shown in Table III. Twenty-nine of the fifty-nine ankles (50 per cent) were immobilised for only eight weeks. There were

TABLE III

PERIOD OF IMMOBILISATION OF THE ANKLE
(Fifty-nine operations)

Period of immobilisation	Number of operations
8 weeks	29
9 weeks	5
10 weeks	5
11 weeks	4
12 weeks	6
14 weeks	1
16 weeks	3
6 months	5
9 months	1

several reasons for the use of longer immobilisation: 1) In eight patients, in whom arthrodesis was performed for tuberculosis, extensive destructive changes had occurred; in two of these, early rehabilitation of the patient was impossible because of the need for treatment of other tuberculous foci in the chest and spine. The six ankles immobilised for six months or more were arthrodesed for tuberculosis, as was one that was immobilised for sixteen weeks and one for fourteen weeks. 2) It was impossible to determine the union of the arthrodesis from

radiological appearances eight weeks after operation (Fig. 5), and the clinical assessment of union was difficult when midtarsal movement masked fusion at the ankle (Fig. 10).

When the post-operative care was not directly supervised by the surgeon who performed the operation there was a tendency to adopt the orthodox programme of three months of

FIG. 1
Case 6—Tuberculosis of the ankle showing the condition before operation.

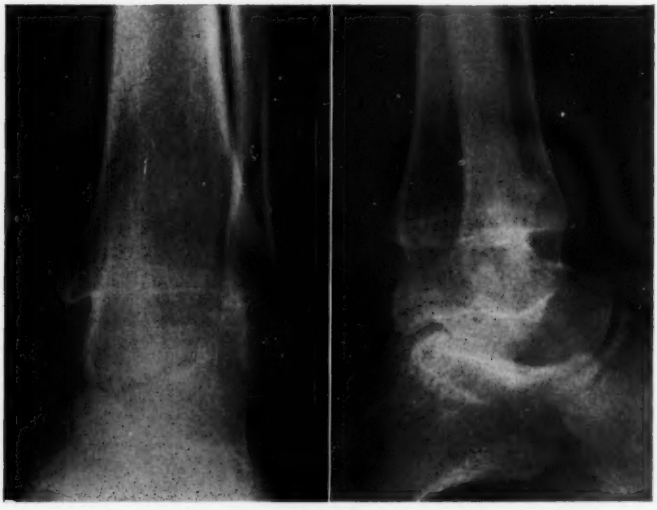

FIG. 2
Case 6—Two years after compression arthrodesis.

immobilisation in plaster. As a result of this study, the routine now recommended after operation is to remove the compression pins at four weeks, then to apply a below-knee walking plaster, and to discard all fixation at eight weeks, regardless of the radiographic appearances.

RESULTS

The incidence of bony fusion and fibrous ankylosis is shown in Table IV. Bony fusion occurred in fifty-four out of fifty-nine ankles (91 per cent) (Figs. 1 and 2). When the arthrodesis was performed for osteoarthritis bony fusion always occurred (Figs. 3 to 6). A distinction must be emphasised between the four patients with a fibrous ankylosis and the one in whom fusion failed. Those with fibrous ankylosis were pleased with the result, and it was impossible to distinguish these ankles from those in which bony fusion had occurred. In two cases a possible explanation for the failure of bony fusion may be offered. One was the first case in which a tuberculous ankle was arthrodesed by this method, and the joint surfaces were not excised with a saw (Fig. 7). In another case, in which arthrodesis had been performed to correct a severe equinus deformity in a patient with spastic hemiplegia, the technique of compression failed four weeks after operation, but a fibrous ankylosis developed after two more months in a walking plaster: it is likely that an inadequate amount of subchondral bone was removed from the lower end of the tibia and from the talus, and therefore compression was not applied between opposing surfaces of cancellous bone. No explanation can be given for the other two occurrences of fibrous ankylosis.

TABLE IV

RESULTS OF COMPRESSION ARTHRODESIS
(Fifty-nine ankles)

Sound bony fusion	54	
Fibrous ankylosis	4	Tuberculosis 2 Poliomyelitis 1 Spastic hemiplegia 1
Fusion failed	1	Charcot ankle

TABLE V

SUBJECTIVE RESULTS OF COMPRESSION ARTHRODESIS
(Fifty-two ankles)

Excellent	36
Good	10
Fair	4
Poor	2

In the one patient in whom fusion failed altogether, the arthrodesis had been performed for a Charcot joint. The joint surfaces came apart after removal of the pins at four weeks, but bony union was secured after a further operation.

The subjective result (the patient's assessment) has been considered in fifty-two out of fifty-nine ankles (Table V). The following seven ankles (five patients) were excluded.

Case 1—A patient, crippled with gross rheumatoid disease of all joints of both lower limbs, had not walked for thirty years. Ankle arthrodesis was performed on both sides to correct an equinus deformity and in the vain hope of helping him to become mobile. He has not walked since, and reported his condition unchanged.

Case 2—This patient, in whom arthrodesis was performed for the effects of an old epiphysial injury in childhood, developed polyarthritis of both knees, hips and wrists a year after the operation. When reviewed, she could just walk a few steps with difficulty, and could give no opinion as to the value of the arthrodesis.

Case 3—A boy aged sixteen with severe old Pott's paraplegia had ankle arthrodesis performed on both sides to correct equinus deformity, in the hope that it would help him to walk. At the time of review he was unable to walk because of gross incoordination of both lower limbs.

Case 4—This patient, in whom arthrodesis was performed for osteoarthritis, reported that the immediate result was excellent. When seen five years later she walked only with sticks and assistance because of osteoarthritis of both hips and of the lumbar spine.

Case 5—A patient with Charcot's disease of the ankle failed to obtain fusion, and the operation was repeated before he walked; therefore the subjective assessment of the result of the first operation was impossible.

The results were most gratifying in forty-six ankles (88 per cent). In two patients the result was classified as poor; in one, in whom arthrodesis had been performed for a failed foot stabilisation after poliomyelitis, the ankle was arthrodesed with too much equinus, and

FIG. 3
Case 7—An old fracture of the ankle before arthrodesis.

FIG. 4
Case 7—The compression clamps applied.

the operation has since been repeated; the other, who had previously had a wedge tarsectomy for a relapsed club foot, alleged that the functional result was worse after the fusion. The result in four patients was classified as fair. Two of these were over sixty when arthrodesis

was performed for osteoarthritis after fracture of the ankle, and both had a marked limp. The third, a patient in whom the fusion was performed after poliomyelitis, was disappointed because a limp remained, though the ankle was stable. The fourth patient classified as " fair,"

FIG. 5

Case 7—The radiographic appearance after removal of the clamps eight weeks after operation. The quality of union is extremely difficult to assess.

FIG. 6

Case 7—Condition two years after operation.

in whom arthrodesis of the ankle was performed for a relapsed club foot, said that the operation had " not made much difference."

Pain—Thirty-four patients had no pain. Sixteen noticed a slight ache after intensive exercise, but it did not limit their activity. Two patients complained of pain.

Gait—The gait was studied in thirty patients after arthrodesis of the ankle performed for purely monarticular lesions such as tuberculosis or osteoarthritis, but was not studied in patients in whom the ability to walk was affected for reasons other than the arthrodesed ankle. In twenty-four patients the gait was classified as perfect, by which is meant that it was impossible, or only just possible on critical inspection, to detect which ankle had been arthrodesed. Four patients showed a mild limp, and two (both over sixty) showed a marked limp.

COMPLICATIONS

In this series there was no serious complication, and no death from operation.

In three ankles the site of entry of the pins was moist four weeks after operation. In two patients the ankle was fused in a faulty position, one in steep equinus and the other with the foot rotated medially on the tibia. The first of these has already been mentioned; the result

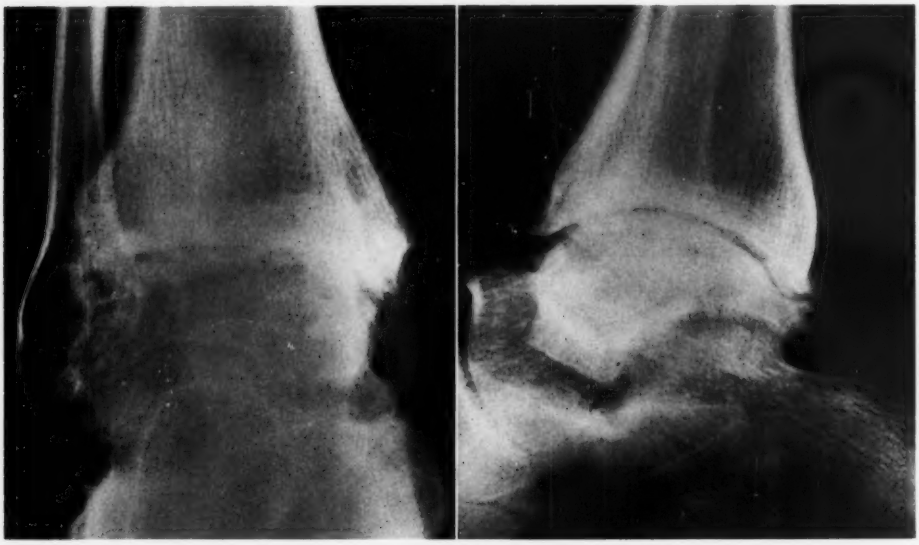

FIG. 7

Case 8—Tuberculosis of the ankle treated by compression arthrodesis which resulted in fibrous ankylosis eight years after operation.

was poor, and the operation was repeated. The other patient was unaware of any abnormality, and the functional result was excellent.

Extensor tendons were adherent to the operation scar in three patients. This was because the skin incision lay over the site of tendon division, instead of distal to it.

Mild oedema of the foot below the operation scar was present in five patients at the time of review. Swelling of the foot was recorded in the documents in fourteen patients during the first year after operation. It was difficult to be exact about the incidence of post-operative swelling and its duration, but it was clear from this review that only rarely does it persist. Two patients required elastic stockings for a diffuse swelling of the leg below the knee. No record could be found in the literature of the incidence of post-operative swelling after arthrodesis of the ankle performed by other methods.

The effect of this method of ankle fusion on subtalar movement was examined in thirty-one ankles. Patients with pantalar arthrodesis, hemiplegia, extensive rheumatoid disease and known stiffness of the subtalar joint before operation were excluded. It was impossible to be

precise in this particular study, because, in many patients, there was no record of the movement of the subtalar joint before operation. Nevertheless, a range of 50 per cent or more of the normal subtalar movement was present after eight out of thirty-one operations. It seems that this operation has an adverse effect on subtalar movement, for which no explanation can be offered.

THE TRANSVERSE INCISION

This operation has been criticised because of the use of a transverse incision, which divides the extensor tendons, the anterior tibial vessels and nerve, and the terminal branches of the musculo-cutaneous nerve. Fifty-five ankles were examined for any consequent ill effects.

Sensation—Four patients mentioned without being questioned that sensation had been lost on the dorsum of the foot. After direct questioning, subjective sensory disturbances were admitted by thirty-nine patients. These were described as " a feeling of numbness," " pins and needles " or " a feathery sensation " over the dorsum of the foot and toes. The symptoms were all mentioned in a casual manner, and no patient seemed in any way troubled by them. In forty-four patients there was a partial loss to touch and pinprick on the dorsum of the

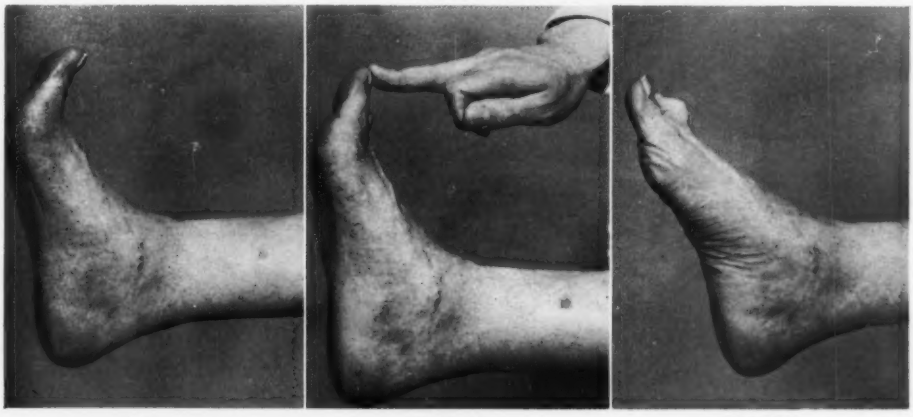

FIG. 8 FIG. 9 FIG. 10

Case 7—Photographs showing the good range of toe extension. Figure 9 shows the power of this movement, and Figure 10 shows the foot in full plantar flexion. The compensatory midtarsal movement masks the loss of ankle flexion. (The hammer deformity of the second toe was present before operation.)

foot below the operation scar. Thus, loss of sensation was usually present, but in no patient was it a serious complaint or disability.

Circulation—No evidence of impaired circulation was found in any patient from division of the anterior tibial vessels. The patients with poliomyelitis were examined particularly in this respect.

Toe extension—The action of the extensor tendons of the toes and tibialis anterior was studied in twenty-six feet. Patients in whom the action of these tendons was impaired before the operation—as in paralysis from poliomyelitis or in spastic equinus—were excluded from this part of the study. Muscle power was assessed by the standard method (Medical Research Council 1942) and the range of dorsiflexion of the metatarso-phalangeal joints measured. Twenty-three of the twenty-six feet showed a good action in these tendons (power 4 or 5), and a range of dorsiflexion at the metatarso-phalangeal joints of 50 per cent or more. In the remaining three patients the tendons were weak, and these results were regarded as poor. No patient complained of inability to move the toes. The extensor hallucis longus was often more powerful than the extensors of the other toes. A typical example in which the range of

movement was good, but not full, is shown in Figure 8. Extension of the toe against resistance is shown in Figure 9.

POSITION FOR ARTHRODESIS OF THE ANKLE

There are many references in the literature to the best position for arthrodesis of the ankle, but these are usually short statements, unsupported by clinical details. Speed and Knight (1956) recommended the right angle as the best position for men with a normal mobility in the other joints of the foot. Barr and Record (1953) preferred a position of 5 degrees of equinus when all the muscles were present and functioning. Adams (1948) recommended "a few degrees of equinus," and Hallock (1945) considered the best position to be 10 degrees of equinus. Watson-Jones (1955) recommended 15 degrees of equinus. He stated: "To arthrodese the foot exactly at the right angle would be satisfactory if our lives

FIG. 11
The method of measurement of the position of ankle arthrodesis.
This ankle was fused in 5 degrees of equinus.

were spent in bare feet, but, since we stand and walk in shoes with heels, it is not satisfactory." Hallock agreed with this opinion, and stated that an undesirable and awkward heel gait results if the ankle is fused at the right angle or less.

Speed and Knight (1956), Watson-Jones (1955) and Barr and Record (1953) agree on the inadvisability of fusion in calcaneus or steep equinus.

A lateral radiograph of the foot and ankle was taken of every patient, standing barefoot with the knees extended. The plane of the sole was outlined by a metal wire. The angle between the plane of the sole of the foot and the line of the tibia was measured, and this was defined as the position of arthrodesis (Fig. 11). This method of assessment of the position of arthrodesis has several advantages. It is simple to perform, accurate, and at the same time takes into account any deformity in the foot other than the ankle. It is a measurement that can help the surgeon while he is operating.

The position after arthrodesis was analysed in the twenty-four ankles previously mentioned in which the gait was classified as perfect (Table VI) (Fig. 12). It will be seen that, with one exception, the ankles of all patients with a perfect gait were arthrodesed either exactly at the right angle or in slight calcaneus or equinus. In the one exception, the operation had been performed for an inversion deformity of the ankle following an old epiphysial injury in early childhood, and the ankle was deliberately arthrodesed in marked equinus to compensate for shortening. The patient wore a surgical boot.

TABLE VI

THE POSITION OF ANKLE ARTHRODESIS IN TWENTY-FOUR PATIENTS WITH A PERFECT GAIT

Angle of ankle arthrodesis	Number of patients
5 degrees of calcaneus	2
Right angle position	10
5 degrees of equinus	11
10 degrees of equinus	—
15 degrees of equinus	—
20 degrees of equinus	1

Of these twenty-four patients, fifteen were men and nine were women. Apart from the one who wore a surgical boot, all the men wore normal shoes with an ordinary low heel. Five of the women preferred low heels, and three preferred heels of moderate height. One

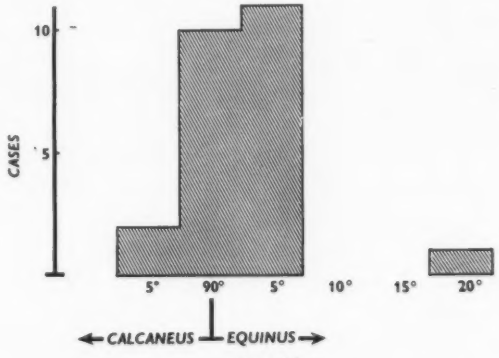

FIG. 12

The position of arthrodesis in twenty-four ankles in patients with a perfect gait.

young adult woman preferred " high heels." The ankle of this patient was arthrodesed in 5 degrees of equinus, yet she had a perfect gait walking either on high heels or barefoot.

Though it appears that the best position for arthrodesis is at, or close to, the right angle, there is no clear evidence relating this position to the type of heel preferred, especially in women.

In contrast to the patients who walked with a perfect gait, it is of interest to analyse the six patients in whom there was a limp. Three were over sixty years of age, and, though the ankle had been arthrodesed in 5 degrees of equinus, the foot as a whole was rigid, with poor

midtarsal and subtalar movements. In the fourth, a young man, the ankle was arthrodesed in 10 degrees of calcaneus, so that the metatarsal heads did not touch the ground when he stood, and he spontaneously remarked that to get the whole foot to the ground he had to bend the knee. The fifth, a woman, had her ankle arthrodesed in 15 degrees of equinus; she said, curiously, that she preferred a low heel and was unable to wear a high one. No explanation can be offered for the mild limp in the sixth patient, a young woman in whom the ankle had been arthrodesed in 5 degrees of equinus.

SUMMARY AND CONCLUSIONS

1. The results of compression arthrodesis of the ankle performed on fifty-five patients (four bilateral) are presented.
2. Fifty per cent of these ankles were immobilised for a total period of no more than eight weeks.
3. Bony fusion occurred in 91 per cent.
4. The subjective result was good or excellent in 88 per cent.
5. The theoretical disadvantages of the transverse incision are not serious in practice.
6. The best position for arthrodesis of the ankle is at, or close to, the right angle.

I would like to express my thanks to Mr D. Ll. Griffiths, the Director of the Department in which this work was carried out, for permission to publish his cases, and to Mr J. Charnley for permission to publish his cases and for reading and criticising this manuscript. I am also grateful to the Department of Medical Illustration of the Manchester Royal Infirmary for the photographs.

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MYOSITIS OSSIFICANS AS A COMPLICATION OF TETANUS

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A forty-three-year-old Indian stepped on a sharp piece of wood and suffered a small puncture wound on the sole of the right foot. A doctor gave him daily injections of penicillin for three days, but no antitetanus serum. Ten days after the injury he was admitted to hospital complaining of pains in his legs, and trismus was observed. He was immediately given an intravenous injection of 100,000 units of antitetanus serum and 600,000 units of procaine penicillin. Later the same day he complained of pain in his back, and this was shortly followed by tetanic spasms in his back and legs. Tetanus was diagnosed. The penicillin was repeated daily for ten days, but no additional serum was given. An intravenous glucose saline drip was started in the right cephalic vein, and paraldehyde was given intramuscularly as required, on an average 8 cubic centimetres five times daily. On the third day the spasms became more frequent and severe, and half a gramme of thiopentone was added to each bottle of saline. After another four days the patient had recovered sufficiently to allow the thiopentone to be discontinued, and the frequency of the paraldehyde injections was reduced. From now onwards the patient made a steady recovery.

On the tenth day after the onset of the spasms the patient complained that both knees and the right elbow were stiff. The stiffness of the right elbow was attributed to a rather painful arm after the intravenous drip, which had been continued for seven days. No thrombosis was noticed. The patient was encouraged to move the affected joints as much as possible, but the stiffness increased, and four days later he was referred to the physiotherapy department for active and passive movements of the knees and right elbow. Examination revealed considerable thickening about the left knee, which felt bony hard, and there was rather less about the right knee. Neither active nor passive movement of the knees was possible. There was marked limitation of movement in both hips, and in the right elbow. Radiographs taken three weeks after the onset of the spasms revealed extensive soft flocculent calcareous infiltration in the soft tissues behind the lower end of the left femur, extending downwards some two inches below the knee joint; and similar, but less extensive, changes behind the right knee. The calcareous infiltration seemed to be mainly in the hamstring muscles or gastrocnemii, and in the medial and lateral ligaments of the knees, though there were similar changes in the medial vasti and adductors on both sides. There was faint flocculent calcareous infiltration in the periarticular tissues of both hips—again a little more pronounced on the left side—and in front of the right elbow in the situation of the lower part of the brachialis. In view of these surprising findings, characteristic of myositis ossificans, the serum levels of calcium and phosphorus were checked and found to be 11 milligrams per cent and 3·1 milligrams per cent respectively. The alkaline phosphatase was 7 units (King-Armstrong), and the Kahn test was negative.

Progress—Complete rest in bed was ordered, with posterior plaster splints to both knees. This treatment was abandoned after two months because no improvement had been achieved, and physiotherapy was instituted. This was discontinued after two months. A year after the onset of tetanus the patient was well, apart from complete immobility of the right elbow, left knee and left hip. There was a limited degree of movement in the right knee (180–165

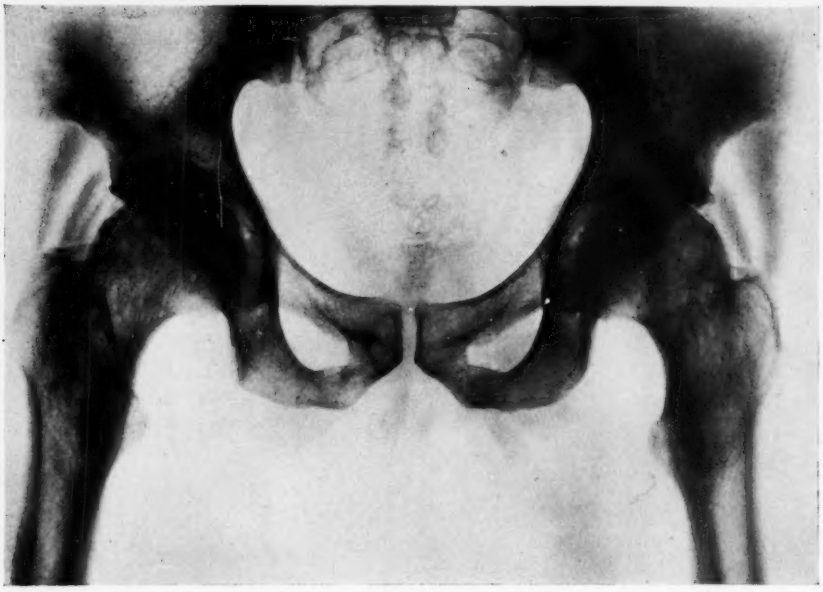

FIG. 1
Early calcification visible in capsular structures of both hips three weeks after onset of tetanus.

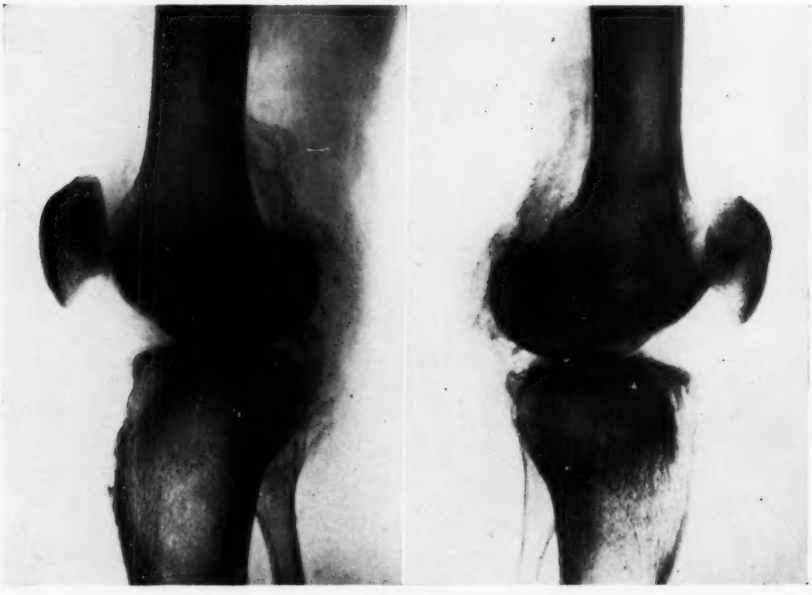

FIG. 2
Radiographs of the knees taken at the same time as the radiograph in Figure 1, showing distribution of ossification in soft tissues.

FIG. 3
Radiograph of pelvis one year later. Broad bands of ossification ankylosing both hips.

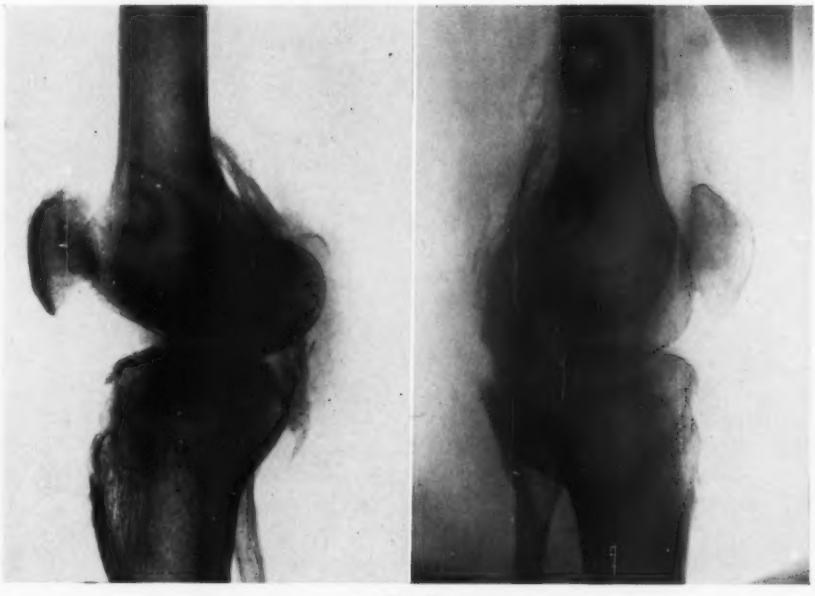

FIG. 4
Knees one year later, showing consolidation into dense bony bands.

degrees) and in the right hip, where it was estimated as 10 per cent of normal. Radiographs showed thick dense bony bands behind both knees, bridging the joints, and similar changes in front of the hip joints and right elbow joint. There appeared to be ossification in the medial ligaments of both knees, more pronounced on the left (Figs. 1 to 5). It was proposed to try to excise the bony bridge from behind one knee, but the patient decided to return home to India and has not been seen again.

ETIOLOGY

We do not know of any previous description of myositis ossificans and ossification in the ligaments and capsules of joints after tetanus. Calcification consists in a slow *passive* deposition of calcium salts in tissues that are either necrotic or of low metabolic activity, and presents as an amorphous shadow in a radiograph. Calcinosis seen in scleroderma and with Raynaud's phenomenon, and the calcification of tendons around the shoulder are good

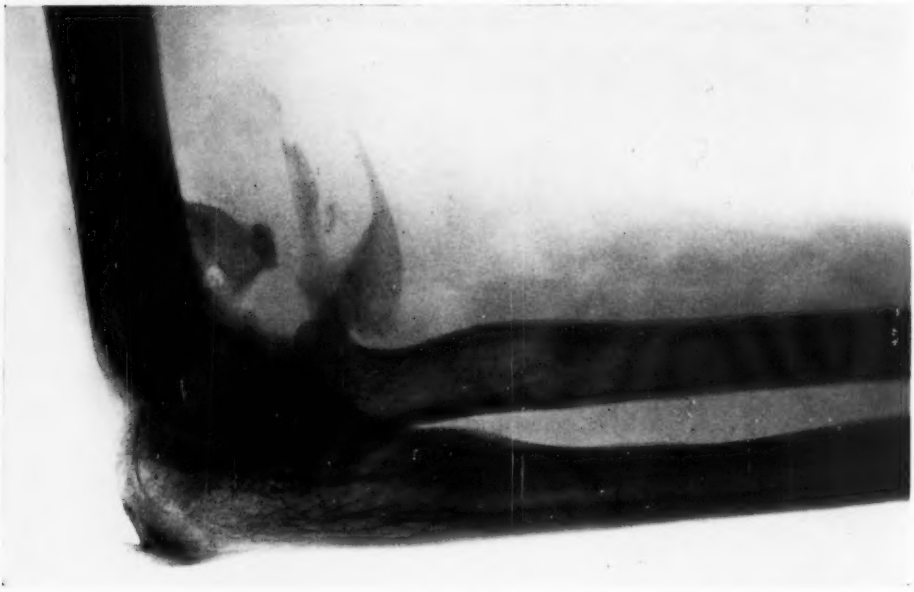

FIG. 5
Right elbow. The changes in the left elbow are almost identical.

examples. The early changes seen here, although presenting an amorphous picture in the radiograph, do not comprise calcification any more than do the similar appearances in the early stages of *active* callus formation in fractures. The indefinite opacity soon matures to one of bone formation, and clearly represents a process of ossification in the involved structures, whether muscles, ligaments or other mesodermal tissues.

Trauma usually precedes such changes; they may occasionally be associated with a fracture, but more often with a dislocation or subluxation, especially of the knee, elbow or hip. The condition is uncommon in open injuries.

Changes which, clinically and radiologically, are indistinguishable from post-traumatic myositis ossificans have been reported with lesions of the central nervous system—more commonly in those affecting the motor system such as traumatic paraplegia, spastic diplegia and anterior poliomyelitis, than in lesions of the sensory system such as tabes and syringomyelia. The condition does not seem to occur with lesions of peripheral nerves, and we have not

encountered it in a fairly large experience of leprosy. It is best described as self-limiting metaplastic ossification in mesodermal tissue, but the term myositis ossificans is universally accepted if the muscles are involved. This local traumatic myositis ossificans must not be confused with myositis ossificans progressiva, which usually, and for no known reason, starts in childhood.

Several theories have been advanced to explain ossification in soft tissues. Déjerine, Ceillier and Déjerine (1919), who were the first to describe ossification in muscles in traumatic paraplegia, ascribed it to the potential of primitive connective tissues under certain conditions to develop into fibrous tissue, cartilage or bone; and suggested that local tissue oedema, with an alteration in the chemical composition of tissue fluids, was an essential feature. Miller and O'Neill (1949) suggested that ossification in spastic lesions was a form of metaplasia brought on by continuous traction on connective tissues, ligaments and tendon; they thought that calcium might be derived from adjacent bones, which initially show rarefaction.

Brailsford (1941) suggested that a lesion of the central nervous system might promote traumatic stripping of periosteum at the site of muscle attachment, or metaplastic ossification. He quoted extensive ossification in the adductor muscles after tenotomy in a youth with spastic diplegia. Watson-Jones (1943) stated that traumatic myositis ossificans was avoidable, and that new bone formation occurred only within the limits of displaced periosteum—being nothing more than ossification of a subperiosteal haematoma. He denied that ossification was caused by the escape of osteoblasts into muscle, and stated that, if displacement of periosteum and extensive subperiosteal haematoma were prevented, ossification would not be encountered. But the pattern of bone formation in ossification of a subperiosteal haematoma is not like that which we are describing, and we cannot accept this explanation.

Costello and Brown (1951), discussing the ossification in muscle in certain cases of anterior poliomyelitis, considered that when tissue atrophy and degeneration are taking place conditions are suitable for metaplastic ossification, especially if there be added the stimulus of trauma; and that factors such as local calcium, phosphorus and phosphatase concentration, and metabolic changes in tissue fluids, might all play a part. Brailsford (1941) suggested that the factor common to all ossification of this type was a lesion of the central nervous system, either purely local and due to trauma, or more central and due to a lesion of the cord, cauda equina or main peripheral nerve trunks.

Clearly there is much difference of opinion over the cause and origin of localised myositis ossificans and similar lesions in other tissues. Is it necessary to seek factors other than trauma to mesodermal tissues? In our case, with its short, violent history, it is hard to believe that there were any factors beyond the trauma from the severe tetanic contractions. This explanation would allow this case to fall into line with the usual picture of myositis ossificans localisata traumatica, differing only in the extent of the lesions from the involuntary self-inflicted trauma to many muscles and joints.

In the treatment of paraplegia and acute poliomyelitis it is customary to employ passive movement of joints. In the presence of muscle spasm which may accompany these conditions, more force may be applied to produce joint movement than is possibly appreciated at the time. In this respect it is interesting that, in many cases of myositis ossificans complicating poliomyelitis, the deposition of bone has first been noted during the early stages of convalescence on an average some twelve weeks after the onset of the illness, and a few weeks after physiotherapy had begun. In Brailsford's case of spastic diplegia, ossification followed operative trauma to muscle. It is known that repeated sudden muscle action may at times be followed by ossification in tendon attachments, and it is not uncommon to find it in the elbow region of athletes who indulge in field events such as throwing the discus and javelin. Heiss (1929) noticed this feature in a high proportion of Olympic athletes examined radiologically; it usually took the form of spurs firmly attached to bone in the region of capsular attachments.

Similar changes have been noted in relation to the lateral condyle of the femur in shoemakers, and in brachialis in pneumatic drill workers. Ossification is occasionally encountered around the hip joints of footballers.

CONCLUSIONS

Ossification of the type we have described usually follows severe trauma: and in this connection a dislocation is usually associated with more trauma to muscle attachments, ligaments and capsular structures than an uncomplicated fracture. In cases associated with lesions of the central nervous system there is almost invariably a history of trauma, or of physiotherapy, or of corrective operations. In those affecting the sensory system it is invariably associated with arthropathy of Charcot type, and repeated trauma to insensible joints or tendons is probably responsible.

Our patient had received physiotherapy for ten days when we first saw him, but this had been instituted because of the increasing stiffness of the joints. We think there is little doubt that, although passive movement in the early stages may have aggravated the condition, the severe muscle spasms of tetanus were the cause; calcareous infiltration in muscle planes was observed in radiographs taken only three weeks after the onset of the spasms, an interval commonly found in post-traumatic myositis ossificans. Furthermore, most of the deposits occurred in the hamstring and flexor muscles of the knee—the muscles most likely to be damaged in the supine position by sudden spasms of knee flexion against the resistance of the distal leg against the mattress—and not in the extensor muscles of the thigh, which would be those most liable to injury on forced passive flexion with the leg free.

SUMMARY

1. Myositis ossificans as a complication of tetanus is described.
2. Ossification in mesodermal tissue is briefly discussed.

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EHLERS-DANLOS SYNDROME PRESENTING CERTAIN UNUSUAL FEATURES

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The Ehlers-Danlos syndrome has been so named from descriptions made by Ehlers in 1901 and Danlos in 1908, although it was first described by Meek'ren in 1682. In 1934 Tobias described the various conditions that may be associated with the syndrome, such as acrocyanosis,

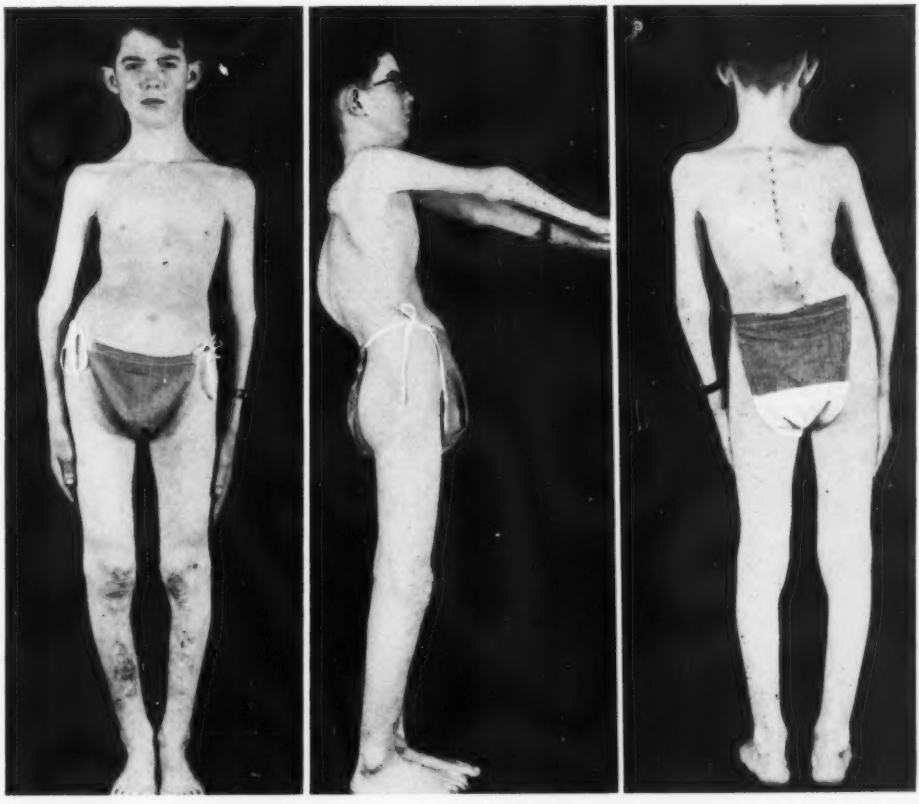

FIG. 1

Case 1—A boy with Ehlers-Danlos syndrome. The widely spaced eyes are typical but the kyphoscoliosis is unusual.

club foot, fibromata, naevi, lymphangiectasis, mental deficiency, supernumerary teeth, syringomyelia, and von Recklinghausen's disease. In 1936 Ronchese emphasised the feature of skin fragility and reviewed the literature; since then numerous articles have appeared, notably that by Johnson and Falls in 1949.

Clinical features—The Ehlers-Danlos syndrome is usually noticed in early childhood. Delay in sitting and walking is associated with widely spaced eyes and a broad nasal bridge (Fig. 1). The skin, which has a lack of subcutaneous tissue, is lax, hyperelastic and velvety: it splits

FIG. 2
Case 1—The skin is loose and hyperelastic, is easily split by minor trauma and heals leaving tissue-paper scars.

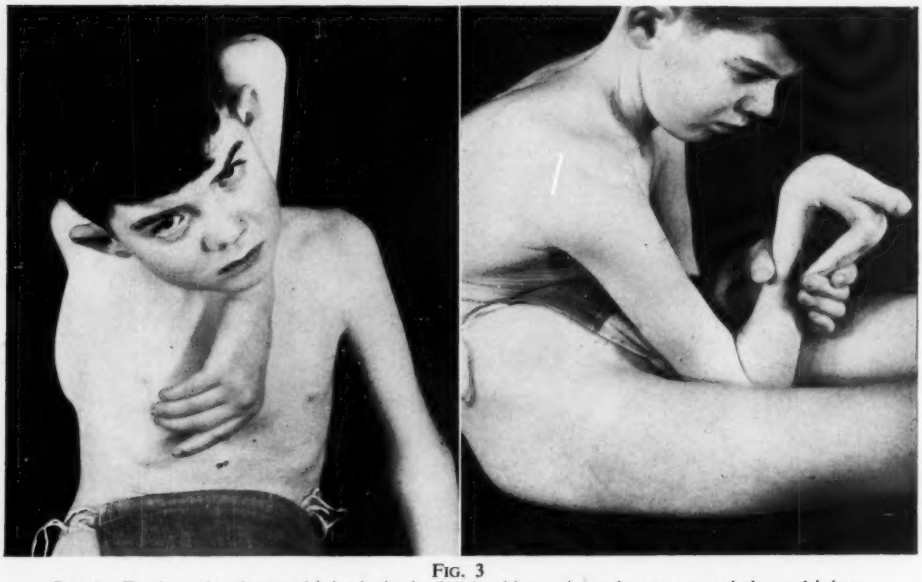

FIG. 3
Case 1—To show the abnormal joint laxity in the shoulder, wrist and metacarpo-phalangeal joints.

easily on minor trauma, being abnormally fragile, and, after delay in healing, leaves typical tissue-paper scars which are atrophic and telangiectatic (Fig. 2). If care is not taken to place sutures well away from the wound edges they will pull out of the skin.

Pseudo-tumours of a molluscoid nature may follow minor trauma, and haematomata form easily—probably not from any abnormality in the vascular walls themselves, but from lack of adequate connective tissue support of the blood vessels.

The laxity of the joints (Figs. 3 and 4), although of advantage to the so-called india-rubber man at the circus, has many attendant drawbacks as it may, with the associated muscle weakness, resemble amyotonia in early life, and leads to sprains, spontaneous dislocations (reported in the shoulder and patella) and collapse of the longitudinal arches of the foot.

Calcified subcutaneous nodules may be present, and because of the general laxity of the connective tissues there is a definite tendency to diaphragmatic and other herniae.

There is usually a family history; genetic studies of affected individuals suggest that the syndrome is transmitted by a dominant gene.

Pathology—The typical changes are a decrease in the collagen fibres, which are less compact than normal, and which are said to be confined to the skin, connective tissue and joints. The elastic fibres seem to be increased and to have a closer grouping, with less separation by collagen

FIG. 4
Case 1—A radiograph of the shoulder to show the appearance at the extreme of abduction.

than is normal. There is a generalised decrease of dermis and subcutaneous tissue, and in the latter fatty nodules may occur, which are enclosed in a fibrous tissue capsule, and which may be calcified. Radiographically these nodules are characterised by dense outer margins and translucent centres.

There is no apparent abnormality of bleeding time, clotting time, platelet count or capillary fragility.

The association of the Ehlers-Danlos syndrome with wedging and deformity of the vertebrae has not been reported. The following case report illustrates this feature and is also of interest in that some of the members of the family on the maternal side have suffered from acholuric jaundice.

CASE REPORT

Boy, aged twelve. *History*—Shortly after birth in February 1946, which was by breech delivery, the baby was observed to have an Erb's palsy of both arms, a thoraco-lumbar kyphosis and a right talipes calcaneus. At the age of one year the arms had recovered but the child had hypermobile joints and could not sit up. When he began walking at two years and eight months the kyphosis became more marked. Despite the provision of a back support, when the boy was eleven, the kyphosis

continued to deteriorate and he was referred to the Robert Jones and Agnes Hunt Orthopaedic Hospital. He said he never played rough games, as cuts always opened widely and healed with difficulty.

Family history—The boy's mother underwent splenectomy and cholecystectomy for acholuric jaundice in 1951, which was followed by normal wound healing. She was also found to have 15 degrees hyperextension of the interphalangeal joints.

The boy's maternal grandmother had normal skin, but early osteoarthritis of the hip, knees and ankles. Her husband, the grandfather, had died at the age of fifty-seven from a stroke, but was said to be normal.

Of four maternal uncles one has 15–20 degrees hyperextension of the proximal interphalangeal joints. The second is normal but has a son with a slight increase of skin elasticity, and hyperextension of all interphalangeal and metacarpo-phalangeal joints as well as 20 degrees of calcaneus of the feet. The third has had a splenectomy for acholuric jaundice with normal healing. He has poor movements in a symptomless lumbar scoliosis. The fourth has also had a splenectomy for acholuric jaundice.

The one maternal aunt is normal.

FIG. 5 FIG. 6

Case 1. Figure 5—The kyphoscoliosis at the age of eleven years. The wedge-shaped vertebrae are most unusual in this condition. Figure 6—The abnormality in the epiphyses of the arm is slight.

The patient's sister has 60 degrees hyperextension of the metacarpo-phalangeal joints, which is less marked in the interphalangeal joints.

A cousin of the boy's mother has a son with thoracic scoliosis and bilateral Sprengel's shoulder, but he was not able to be examined. His case notes show no other record of skin or joint abnormality.

The boy's father, paternal grandparents and one surviving paternal uncle appear to be normal.

Examination—The child was underdeveloped for his twelve years, being 3 feet 10 inches in height. He was myopic and stood with a fixed thoraco-lumbar kyphoscoliosis (Fig. 1) with hypermobility of the spine above and below; he could rotate the cervical spine through 220 degrees and touch his seventh cervical vertebra with his occiput. The elbows and knees appeared fusiform, and the legs were bowed. Atrophy of the pectoral muscles has left a depression below each clavicle. There were numerous tissue-paper scars on the legs and forehead. The skin felt velvety and was very elastic (Fig. 2). The wrists and metacarpo-phalangeal joints were hypermobile (Fig. 3) and the shoulders abducted to 225 degrees (Fig. 4). The elbows and hips showed slight restriction of movements but the knees, subtalar and interphalangeal joints were normal.

Investigations—The boy had a normal haemoglobin, red and white cell counts, blood urea and renal function. Other biochemical tests showed:—

Serum sodium	280 milligrams/100 millilitres: 122 mEq/litre.
Serum potassium	17·0 milligrams/100 millilitres: 4·4 mEq/litre.
Alkali reserve	58 millilitres CO_2 /100 millilitres: 26 mEq/litre.
Alkaline phosphatase	15 units.
Serum calcium	9·8 milligrams/100 millilitres.
Serum inorganic phosphate	4·4 milligrams/100 millilitres.
Basal metabolic rate	+14 per cent.

Radiography—The thoraco-lumbar spine showed wedge-shaped vertebral bodies (Fig. 5). The other bones were to all intents normal with the exception of slight irregularity of the humeral, radial and lower ulnar epiphyses (Fig. 6).

Treatment—The kyphosis is being corrected and it is hoped to perform a spinal fusion ultimately.

DISCUSSION

This patient shows many of the features of Ehlers-Danlos syndrome, with the typical hyperelastic, velvety skin, loss of subcutaneous tissue, skin fragility and hypermobile joints. The unusual features are: 1) some joints show restricted movement; 2) the thoraco-lumbar kyphosis and wedge-shaped deformity of the vertebral bodies bring to mind similar changes seen in chondro-osteo-dystrophy. Gargoylism and achondroplasia are excluded in this patient.

It is also unusual to find no genetic background in the family history, in which there is little abnormality except the acholuric jaundice.

I should like to thank Mr Gordon Rowley and Mr Robert Roaf for permission to publish this case and Miss Norah Walker for her advice on the radiographs.

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THE RESULTS OF TREATMENT OF MALLET FINGER

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Mallet finger is the deformity caused by a tear of the extensor expansion from its attachment to the base of the terminal phalanx. Sometimes there is an associated fracture caused by avulsion of a small triangular fragment of bone. The terminal phalanx is flexed and the power of active extension is lost, and there may be a secondary hyperextension of the proximal interphalangeal joint due to the exertion of the full power of the extensor mechanism of this joint.

The method of treatment generally recommended for a mallet finger, particularly if it is seen within a few days of injury, is immobilisation by a plaster splint in the position of hyperextension of the distal joint and flexion of the proximal joint for four to six weeks. The impression created is that the immediate results of this treatment are good (Smillie 1937, Watson-Jones 1940).

The present review was carried out to assess the long-term results of treatment, and in particular to determine whether or not freedom from disability and restoration of full movement were achieved.

MATERIAL

Seventy-five patients with mallet finger treated in the surgical out-patient department of the Royal Infirmary of Edinburgh during the years 1952, 1953 and 1954 were reviewed. The shortest time that had elapsed between the injury and the follow-up examination was one year.

ETIOLOGY

The highest incidence was found in the fifth and sixth decades, and men were affected more often than women. The ring and little fingers were injured in fifty cases, the middle and index fingers in twenty-four cases, and the thumb in only one case. These findings are in general agreement with other reported series (Mason 1930, Smillie 1937, Ratliff 1947).

Industrial injuries and accidents in the home, especially during bed-making, accounted for most cases. The alleged common cause—sports, such as cricket—was not encountered in this series.

In thirty of the seventy-five cases there was radiological evidence of a fracture at the time the patient was first seen.

METHOD OF TREATMENT

Sixty-nine patients were treated by immobilisation in plaster in the position of hyperextension of the distal interphalangeal joint and flexion of the proximal joint. An analysis of those cases, however, showed that in only thirty had a satisfactory plaster been maintained for at least four weeks. In the others a change of splint had been required because the plaster had become too tight, too loose, or had become soft through getting wet. Sometimes the plaster had come off and had not been replaced, usually because the patient had not reported to hospital.

Two patients had no treatment and four had operative repair of the ruptured tendon.

RESULTS

Subjective—Any complaints made by the patients were recorded and, in particular, each patient was specifically asked about discomfort or any interference with normal activities.

One patient stated that persistent deformity and lack of power caused considerable inconvenience in the course of her ordinary household activities inasmuch as she constantly tended to knock her finger and " it caught on things." She had been treated by uninterrupted immobilisation of the finger in plaster for six weeks.

Five patients complained of occasional discomfort in the region of the terminal interphalangeal joint, especially during cold weather. One had severe constant pain from osteoarthritis in the joint.

The striking finding at the time of examination was the complete absence of symptomatic disability in all but the above. However, questioning elicited the fact that this freedom from trouble was not generally an immediate sequel to the end of treatment. The usual course was a slow improvement over several months from the time of injury.

Objective—The range of movement at a normal distal interphalangeal joint was found to show great individual variation. For this reason active and passive movement of the affected joint was compared with the corresponding joint of the opposite side and any limitation of flexion or extension was expressed as a percentage of the normal range for that individual patient (Table I).

TABLE I

RANGE OF MOVEMENT AFTER TREATMENT (71 CASES)

Active movement	Number of cases	Per cent
Full range . .	16	22·5
75–100 per cent .	47	66·0
50–75 per cent . .	6	8·5
Less than 50 per cent	2	3·0

A perfect anatomical result was obtained in less than a quarter of the total, and a severe deformity was still present in approximately a tenth. Of the fifty-five patients with some restriction of active movement, twenty-eight (51 per cent) had a full range of passive movement.

In the analysis of the results of treatment the following factors were specifically noted.

Immobilisation—There was no significant difference between those cases in which uninterrupted immobilisation in hyperextension for at least four weeks had been carried out, and those in which immobilisation had been inefficient for the reasons described above. Indeed, many patients stated that after removal of a plaster which had been considered satisfactory the affected finger was stiff for a few days and then the mallet deformity recurred. Over a variable time thereafter the deformity slowly but steadily decreased until the final state of recovery was reached. No further improvement was ever noted after six months from the time of injury. This also proved true for those patients who had unsatisfactory splints and for the two individuals who had no treatment.

Early treatment—There was no difference in the ultimate outcome between patients who had treatment within three days of the injury and those in whom the start of the treatment had been delayed for up to three weeks.

Fracture—The presence of an associated fracture in thirty cases did not affect the incidence of persistent deformity, but did increase the liability to subjective complaints. Four of the five patients who complained of discomfort had sustained a fracture.

Operation—Of the four patients who had operative repair of the ruptured tendon one complained of discomfort. Only one had a perfect anatomical result: in the other three there was an average restriction of extension by 20 degrees and of flexion by 10 degrees at the distal interphalangeal joint.

Complications of treatment—Ten patients had pressure sores, eight of which were over the dorsal aspect of the distal interphalangeal joint, and the scarring associated with healing had caused some limitation of flexion. Since the completion of this follow-up, one patient has been seen in whom too tight a plaster had caused gangrene of the terminal phalanx, necessitating partial amputation of the finger.

DISCUSSION

The principle of treatment by hyperextension of a mallet finger is based on the fact that flexion of the proximal joint fixes the middle slip and allows the two lateral bands of the extensor aponeurosis to be approximated to the site of their distal attachment.

Many types of splint have been devised to maintain this position, but the most popular method is the application of a plaster. There are two problems associated with its use: 1) *Application*—The different techniques described by Smillie (1937), Bunnell (1944), Howie (1947), Williams (1947) and Watson-Jones (1956) indicate the difficulty of fitting an efficient plaster. 2) *Maintenance*—In this series less than half the patients were considered to have had a satisfactory plaster for the reasons already given. Any change of plaster during the period of immobilisation may allow flexion of the distal interphalangeal joint—even though it be momentary—and upsets the principle of treatment.

The present review indicates that the mechanical difficulties of plaster immobilisation of a mallet finger with flexion of the middle joint are considerable and thus confirms the observations of other writers (Rosenzweig 1950, Pratt 1952). It shows that on removal of the plaster the immediate results may be satisfactory but that in many cases the deformity recurs. Duncan (1948) noted that on removal of the plaster there was invariably a fully extended joint but that within forty-eight hours the flexion deformity recurred in approximately half of the patients treated. The poor early results of conservative treatment have caused some surgeons to carry out immediate operation. Pratt (1952) advised internal fixation of the joints of the fingers by a Kirschner wire to maintain the desired position for six weeks, and Mason (1930) recommended early operative repair of the ruptured extensor expansion.

The results of operative repair are not always satisfactory. The cosmetic effect may be good but the restoration of a full range of movement is uncommon. In fact, movement is often less than after conservative treatment: in particular, flexion of the distal interphalangeal joint may be restricted by scarring on the dorsal aspect, as was noted in three of our four patients who were treated by operation. Rosenzweig (1950) also considered that " the results of operative repair left a lot to be desired."

The assessment of the late results in this series suggests that early operative repair is unnecessary. Improvement occurs gradually as healing and contraction of fibrous tissue proceed, and, although lengthening of the tendon is responsible for a high incidence of incomplete extension, the subjective end results are good. This assessment is in agreement with that of Rosenzweig (1950), and suggests that a satisfactory state of recovery will occur in practically all cases of mallet finger even if no treatment is given. The finger may be strapped with adhesive strapping or a straight spatula splint may be applied to the palmar aspect of the fingers to relieve the initial discomfort associated with the injury. This form of treatment, which is easy to apply, comfortable for the patient and devoid of the risk of pressure sores, is now being used in this department.

CONCLUSIONS

1. The method of treatment of a mallet finger deformity by immobilisation in a plaster in the position of hyperextension of the distal interphalangeal joint and flexion of the proximal interphalangeal joint is, on the whole, unsatisfactory because the splint is difficult to apply, it may need to be changed frequently, and it is sometimes complicated by pressure sores.
2. In many cases the deformity is still present after six weeks of adequate immobilisation, but gradual improvement from the contraction of fibrous tissue occurs for up to six months.

Therefore an assessment of the results of any method of treatment should be made only after an interval of at least six months.

3. The subjective end results at the end of six months are satisfactory whether or not there has been efficient immobilisation in hyperextension. Few patients have any disability and only rarely is this sufficient to cause interference with normal activities. A high proportion of patients show slight persistent deformity and limitation of movement, and this is seemingly uninfluenced appreciably by the type or duration of treatment.

4. The only treatment necessary for most cases of mallet finger is the application of elastic adhesive strapping or a straight spatula splint in order to relieve the initial discomfort from the injury.

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HIP MECHANICS

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The object of this paper is to illustrate how forces that are much greater than the weight of the whole body can be transmitted by the hip joint. Variations under different conditions are illustrated.

For many years it has been understood how the hip joint may act as the fulcrum of a lever system. In 1889 Braune and Fischer published work on the location of the partial centres of gravity in relation to the cardinal planes of the body. Pauwels (1948), in a paper which referred especially to stress in long bones, discussed some of the essential factors governing joint pressure. Inman (1947), in an article dealing with the function of the abductor muscles, considered the relationship between the angle of application of the gluteal muscles to the greater trochanter, and joint pressure. Steindler (1955) summed up existing knowledge, and concluded that mathematical calculations were of value despite the aggregate inaccuracies of basic information.

For the purpose of calculation it can be assumed that the mass of a body is concentrated in one place. This is called the centre of gravity. The line which joins this point to the centre of the earth is called the line of body weight.

FIG. 1

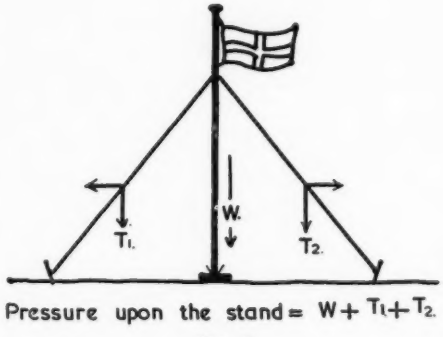


FIG. 2

FIG. 3

FIG. 4

Figure 1—Balance is maintained by the coordination of muscle groups. Figure 2—The force which the stand must support is greater than the weight of the flag and the pole. Figure 3—When the subject stands on one foot the line of body weight divides the body into two balanced halves. Figure 4—If one leg is abducted other movements must be made to restore equilibrium.

Figure 1 is a diagram of a subject standing on two legs. He balances in the position of least effort by co-ordinating opposing muscle groups. In this position each ankle joint has to transmit not only half the body weight, but a little more. This is because the balancing muscles are under tension and this tension must be added to the supported body weight.

Compare this with a flagpole upon a stand (Fig. 2). The stand must support the weight of the pole in the same way as the ankle joints support the body weight. The two guy ropes correspond to the balancing muscles. These ropes are exerting some tension and the vertical component of this tension increases the weight which the stand must support to W+T.1+T.2. This extra weight is not great when the pole is perpendicular but if it leans to one side the tension in one rope is enormously increased, and therefore so is the pressure upon the stand.

What happens when the right foot is lifted from the ground? The reaction to one line of weight transmission is lost, and if no alteration in position occurs the subject falls to his right. However, if he is to remain standing, he must lean very slightly to the left (Fig. 3). In this position the line of body weight, which passes through the centre of the foot, divides the body into two balanced halves.

If the right leg is abducted (Fig. 4) its rotatory effect in that direction must be counterbalanced, and the subject must lean a little more to the left, abducting his left arm and hip and adducting his right arm. This brings the line of body weight back until it is once more passing through the centre of the foot and again the right and left sides of the body are balanced.

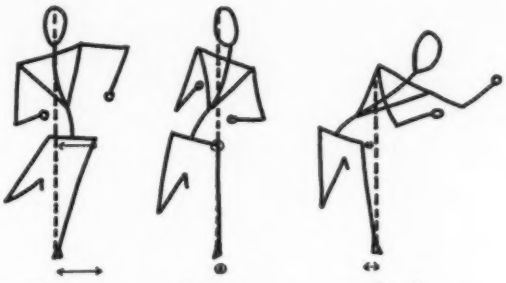


FIG. 5 FIG. 6 FIG. 7

There is no constant relationship between the hip joint and the line of body weight. This can easily be changed.

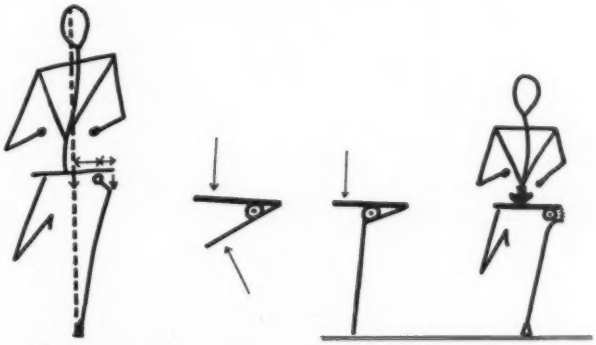


FIG. 8 FIG. 9

Figure 8—A simple algebraic equation can be used to relate forces acting about the hip joint. Figure 9—The femoral head may be compared to a nut inside a nut cracker. Forces much greater than the weight of the whole body can pass through the hip joint.

Although the line must always pass through the centre of the foot its relationship to the hip joint can be easily varied. When the subject leans to his right the line passes to the medial side of the hip joint (Fig. 5). When he leans a little to the left it can pass through the femoral head (Fig. 6), and if he leans more to the left it will pass lateral to the hip (Fig. 7). However, the most convenient position for the line is medial to the hip joint. In this position a considerable anti-clockwise force is exerted upon the pelvis. This force must be counterbalanced by the abductor muscles.

The hip acts as the fulcrum of a lever system. Figure 8 shows the bar of the lever—the pelvis; the fulcrum—the femoral head; and the two forces acting upon the lever bar. The one

on the right is the body weight (less the weight of the supporting leg), and the other the pull exerted by the gluteal muscles to keep the pelvis level.

The femoral head may be compared to a nut inside a nut cracker (Fig. 9). The hinge has been replaced by a piece of very strong elastic which represents the gluteal muscles. The pelvis is represented by one handle of the cracker. If the other handle is elongated, bent and balanced upon the ground, and if a force is applied to the " pelvic " handle as illustrated, it is seen that the weight passing through the femoral head is much greater than the total body weight because the joint is acting at a mechanical disadvantage.

The distance between the line of supported body weight and the hip joint is of considerable importance (y'' in Fig. 10). It is controlled by the obliquity of the pelvis, and the position of the head and trunk and of the three limbs. No one factor is wholly responsible. If the position of the pelvis is to be maintained the turning moments about the femoral head must be equal. Thus, the two distances y and z and the supported body weight being known, the vertical component of the gluteal force X which is theoretically necessary to maintain the position of the pelvis can be calculated. The factors that cause alterations in hip joint pressure are just those factors that influence any simple lever system.

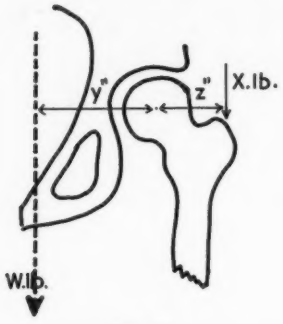


FIG. 10

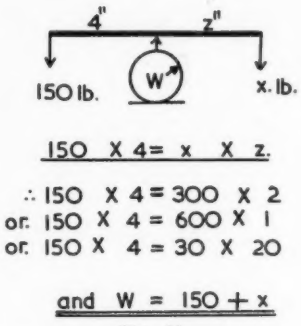


FIG. 11

Figure 10—Where W = the supported body weight, y = the distance between the line of supported body weight and the hip, X = the vertical component of gluteal tension, and z = the distance between the insertion of the gluteal muscles and the hip, $W \times y = X \times z$. Figure 11—In a simple lever system the weight supported by the fulcrum (W) is the sum of the weights acting at each end of the lever bar ($150 + x$).

If the bar of a simple lever system is to be balanced, the turning moments about the fulcrum must be equal. If at one end of the lever 150 lb. is acting at four inches from the fulcrum (Fig. 11) the rotational effect in an anti-clockwise direction can be counterbalanced by either 300 lb. at two inches (if we neglect the weight of the lever bar); or 600 lb. at one inch; or again 30 lb. at twenty inches. But although balance is achieved in these three examples the weight supported by the fulcrum is different in each case. The weight supported by any fulcrum is the sum of the weights acting at each end of the lever bar. Thus in the first example $150 + 300 = 450$, and the weight supported by the fulcrum in this case is 450 lb. In the second example, 750 lb. is transmitted to the scales, and lastly the total weight is only 180 lb. These variations in pressure are similar to those in the hip joint.

The next important fact to appreciate is illustrated as follows. If, instead of having the weight of 150 lb. attached as it is in Figure 11, it is mounted as shown in Figure 12, the anti-clockwise rotational force is just the same as in the previous examples (when the bar is horizontal) and, as before, the force of 300 lb. at two inches will be required to balance the system. But if we bend the support (Fig. 13) the weight is still attached four inches from the fulcrum but its leverage or rotational effect upon the bar in an anti-clockwise direction is

only half as great as it was before and it can be balanced by half the clockwise turning moment that was previously required. Furthermore, if the supporting arm is bent until the centre of gravity of the left side of the system is directly over the fulcrum (Fig. 14) the machine is in equilibrium and no force is needed upon the right arm of the lever bar. Now the fulcrum has only to support 150 lb.; this is the position of least fulcrum stress. If the supporting arm were to be bent farther still (Fig. 15) the lever system would rotate in a clockwise direction

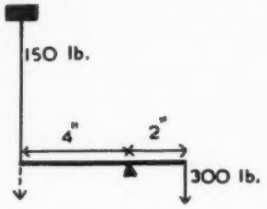


FIG. 12

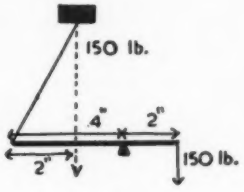


FIG. 13

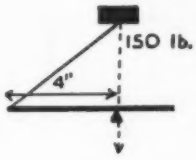


FIG. 14

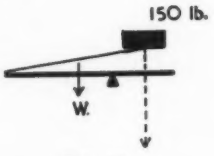


FIG. 15

FIG. 16

Figure 12—When the lever bar is horizontal this lever system will balance. Figure 13—The supporting arm holding the 150 lb. has been bent. Now balance can be maintained by a smaller weight on the right arm of the lever bar. Figure 14—If the 150 lb. is held over the fulcrum no clockwise balancing moment is needed. Figure 15—If the 150 lb. weight is suspended above the right arm of the lever bar the balancing weight (W) would be needed on the left side of the lever system. Figure 16—It is important to differentiate between the path of weight transmission (P.W.T.) and the gravitational line of weight (G.L.W.).

unless a balancing weight were added in the position shown. Observe how the two weights are attached to the same side of the lever bar and yet their rotational effects are opposite. It is essential to appreciate the difference between the path of weight transmission (P.W.T. in Fig. 16) and the gravitational line of weight (G.L.W.).

THE PRACTICAL APPLICATION

As a basis for calculation (Fig. 17) let us assume that an average patient's weight, minus the weight of the supporting leg, is 150 lb.; that the distance between the line of supported body weight and the centre of the femoral head is four inches*; that the horizontal distance between the greater trochanter and the fulcrum is two inches, and that the vertical component of the force exerted by the abductor muscles to maintain pelvic position is x lb. Then $150 \times 4 = x \times 2$ and so the gluteal muscles must pull the greater trochanter towards the pelvic brim with a force of 300 lb., and consequently the joint must support a pressure of 450 lb. This theoretical calculation explains why such enormous forces are needed to break the normal femoral neck (Evans, Pedersen and Lissner 1951) and why an arthroplasty prosthesis should probably be capable of transmitting at least two or three tons without failing.

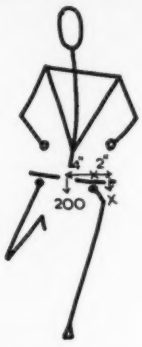
Now let us consider what happens if the patient's weight changes (Fig. 18). Suppose that he puts on weight from the original 150 lb. to 200 lb.: how does this affect the joint

* No satisfactory clinical or theoretical method of finding this distance has been found in the literature. The author believes that the methods suggested by Osborne and Fahrni (1950) may not be completely correct. In this paper the question is not fully discussed, and the line of total and supported body weight are assumed to occupy the same position.

pressure if the two basic measurements remain the same? It can be calculated that the gluteal tension must be 400 lb. and so the joint pressure must have increased to 600 lb. There has been an increase in joint pressure of 150 lb. because of an increase in body weight of only one-third

150 X 4 = x X 2
x = 300
Joint pressure = 150 + 300
= 450.

FIG. 17



200 X 4 = x X 2
x = 400
Joint pressure = 400 + 200
600.

FIG. 18

150 X 4 = x X 1
x = 600
Joint pressure = 600 + 150
750.

FIG. 19

FIG. 17—Some basic measurements are assumed to enable simple calculations to be made. Figure 18—A small increase in body weight causes a great increase in joint pressure. Figure 19—Joint pressure is greatly influenced by the length of the femoral neck.

of that amount. We can conclude therefore that if the joint pressure is to be reduced, thus diminishing the work done by the hip joint, the patient's weight should be reduced. The loss of 1 lb. of body weight could relieve the joint of 3 lb. pressure.

FIG. 20

FIG. 21

A long femoral neck is a mechanical advantage to hip function, but if a prosthesis is set well into the bone, fixation is more certain.

The next factor to consider is the horizontal distance of the insertion of the gluteal muscles from the fulcrum (Fig. 19). This measurement is directly related to the length of the femoral neck. In the original diagram (Fig. 17) this distance was two inches. If it is assumed that operation or disease has shortened the neck until this measurement is reduced to one inch, what is the effect upon joint pressure? The gluteal force must equal 600 lb. and the joint pressure is theoretically 750 lb. There has been a rise of 300 lb. in pressure simply because the functional length of the femoral neck has been reduced from two inches to one inch. It is concluded therefore that the preservation of the length of the femoral neck should be a most important consideration in arthroplasty.

Nevertheless, at operation a balance must be struck between mechanical advantage and mechanical failure. The arthroplasty illustrated in Figure 20 would have a great mechanical advantage, but the mechanical failure rate would be high because the ratio of supported acrylic to unsupported acrylic is high. In the arthroplasty illustrated in Figure 21, because of the mechanical disadvantage, fixation is much more certain.

The next consideration is the position of the fulcrum itself. By surgical means the femoral head can be displaced inwards; acetabular bone is removed and the area of contact between

the pelvis and the femur is shifted medially. Suppose that from the original diagram (Fig. 17) the femur is displaced inwards upon the pelvis one inch by acetabular excavation (Fig. 22). It can be calculated that x=225lb. and the joint pressure is therefore only 375 lb. There has

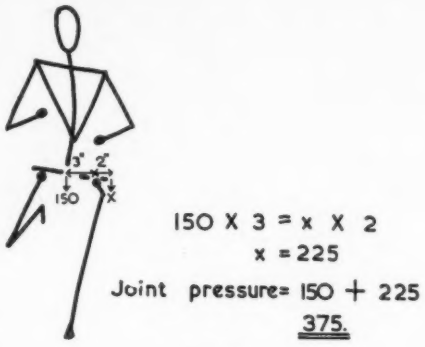


FIG. 22

If the distance between the line of supported body weight and the hip is reduced, there will be a considerable reduction in joint pressure.

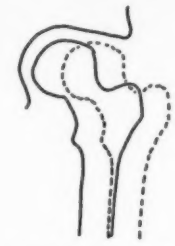


FIG. 23

FIG. 24

Medial displacement of the femoral head upon the pelvis will result in a great reduction of hip joint pressure, whereas displacement of the femoral shaft upon the head and neck has no influence upon hip mechanics.

been a reduction in joint pressure of nearly three-quarters of a hundredweight simply because the femur has been displaced inwards one inch. Medial displacement of the femur upon the pelvis, a basic principle of orthopaedic surgery, is illustrated in this manner.

However, medial displacement of the femoral head (Fig. 23) should be sharply differentiated from the simple medial displacement of the femoral shaft upon the head and neck. Although this manoeuvre (Fig. 24) may alter the blood supply to the hip joint, it has no effect whatsoever upon the mechanics of the joint.

The next factor to consider is the distance of the line of supported body weight from the hip. In the original diagram this distance was four inches. What alterations in joint pressure occur if this is reduced from four inches to three inches? The calculations are the same as in

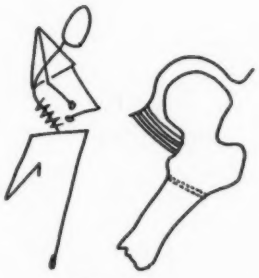


FIG. 25

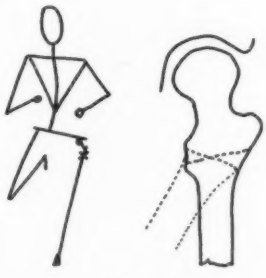
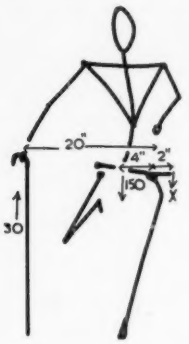


FIG. 26

A fixed adduction deformity causes increased joint pressure and low back strain. Both these are greatly relieved by an abduction osteotomy.

the last example (Fig. 22) and, as before, the joint pressure is 375 lb. This illustrates how joint pressure is greatly decreased as the line of supported body weight is moved towards the hip joint, a change which can easily be made. In this connection it should be noted that if a

patient who has a stiff osteoarthritic spine suffers from a hip which is deformed in adduction (Fig. 25) he will have considerable difficulty in moving the line of body weight towards the hip joint. Therefore an abduction osteotomy (Fig. 26), besides relaxing the shrunken capsule, diminishes gluteal tension, reduces joint pressure and relieves the strain on the back. This does not apply to a normal hip, where an abduction osteotomy would increase joint pressure by reducing the functional length of the femoral neck.



$$150 \times 4 = (x \times 2) + (20 \times 30)$$

$$x = 0$$

$$\text{Joint pressure} = 150 - 30$$

$$120.$$

FIG. 27

A walking stick can relieve the hip joint of pressure which is very much greater than the thrust applied to the stick.

The last factor which must be considered is the effect of a crutch or a walking stick (Fig. 27) upon the hip mechanics (Pauwels 1935, Denham 1955, 1956; Blount 1956). If it is assumed that the subject presses downwards upon a stick held twenty inches from the fulcrum with a pressure of 30 lb., what is the effect upon the mechanics of the hip joint? The walking stick and the abductor muscles are both exerting a clockwise turning moment, whereas the body weight is attempting to rotate the pelvis in an anti-clockwise direction. By calculation $x=0$. Under these circumstances therefore the hip is completely stabilised by the walking stick. No tension is required from the gluteal muscles to prevent the pelvis from sagging on the unsupported side. Furthermore, instead of pressing upon the lever bar the 30 lb. reaction is upwards; consequently the weight which must be supported by the joint is 150 −30 lb. and the force passing through the hip is only 120 lb. It is concluded therefore that the relief of joint pressure afforded by a walking stick can be out of all proportion to the thrust exerted from it. A walking stick, properly used, remains therefore the most satisfactory mechanism available for relieving joint pressure and reducing the work done by hip muscles.

SUMMARY

1. The hip joint usually acts as the fulcrum of a lever system.

2. The centre of gravity of supported parts, which is usually medial to the hip joint, exerts a rotational effect upon the pelvis. If pelvic position is to be maintained this force must be counterbalanced by hip muscles.

3. The force transmitted by the hip joint is the sum of the supported body weight and the tension in the balancing muscles. This force often exceeds the total weight of the body.

4. In some circumstances the loss of one pound of body weight relieves the hip joint of three pounds pressure.

5. A long femoral neck is an advantage to hip function, but in arthroplasty this must not lead to mechanical failure such as breaking or loosening of the prosthesis, or fracture of the bone.

6. Medial displacement of the femoral head upon the pelvis may cause a great decrease in joint pressure, but medial displacement alone of the shaft upon the head and neck does not influence the mechanics of the joint.

7. The position of the centre of gravity of supported parts is easily altered by slight variations in spinal position. Great changes in hip joint pressure are caused by small coronal spinal movements, but the advantage to man of being able to walk with the eyes steady outweighs the mechanical disadvantage to which his hip is subjected.

8. A femoral abduction osteotomy improves the mechanics of a hip joint deformed in adduction.

9. A walking stick or a crutch is most helpful in relieving joint pressure and reducing the work done by hip muscles.

APPENDIX

For simplicity three factors have been omitted. These are: the difference between the positions of the lines of supported and total body weight; the angle of application, the point of insertion of the gluteal muscles and the muscular division of labour; and the effects of locomotion on joint pressure. These points had been omitted because in no case would their consideration have resulted in joint pressures lower than those quoted.

The position of the lines of supported and total body weight—Localisation of the position of the centre of gravity of those parts supported by the hip joint is perhaps possible, and a more accurate estimation of the exact rotational force exerted upon the hip could be made from the following equations: 1) Rotational effect $=W_1 \times (a+x)$. 2) $\text{Sin}\,\alpha$ degrees $=a/f=b/e=c/d$. 3) $W_1x=W_2b+W_3c$ (Fig. 28)—where W_1 represents the body weight less the weight of the supporting leg, W_2 the weight of the thigh, and W_3 the weight of the leg and foot; where a, b and c are respectively the distances between the hip joint, the centre of gravity of the thigh and the centre of gravity of the leg and foot, and the line of total body weight; where f, e and d are respectively the distances between the hip joint, the centre of gravity of the thigh and the centre of gravity of the leg and foot, and the ground; and where α degrees is the angle between the vertical and the lower limb.

It will be seen that for hip joint calculations x is probably small (resulting in an error of about 5–10 per cent); thus if in estimating pressure in other joints x is disregarded results will be very accurate for ankle joint pressures, quite accurate for patello-femoral and tibio-femoral pressures, but inaccurate for low spinal and very inaccurate for high spinal calculations.

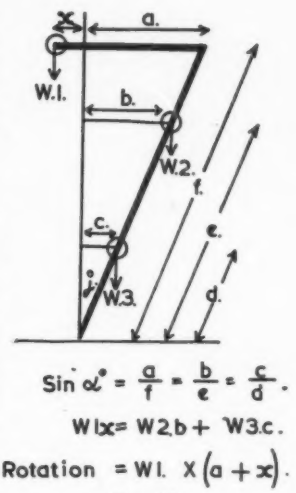


FIG. 28

From these equations the distance between a joint and the centre of gravity of supported parts can be found. X can be disregarded in the estimation of ankle, knee and hip joint pressures, but not in spinal calculations.

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EXTERNAL COUNTING OF Ca^{47} AND Sr^{85} IN STUDIES OF LOCALISED SKELETAL LESIONS IN MAN*

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In isotope experiments in animals it is sometimes useful to make serial sampling of critical organs in addition to blood and excreta. In man it is often impossible or undesirable to make such a sampling. Here the external counting technique has proved useful—for example, for measurements over the thyroid of the I^{131} radiation after administration of this isotope. Improved equipment and new γ-emitting isotopes and isotope compounds have expanded the applicability of external counting techniques to a wide variety of problems, including those of haematology, cardiology, liver and kidney metabolism.

The use of external counting techniques for study of problems in bone metabolism has formerly been hampered by the lack of suitable isotopes. This situation has now improved, and in a previous communication (Bauer and Ray 1958) it was shown how external counting of Sr^{85} in man might furnish useful data for an interpretation of the kinetics of strontium metabolism in particular, and also of bone metabolism in general. These results and earlier experiments on fracture healing in rats (Bauer 1954) suggested that external counting techniques might be of special interest in the study of localised skeletal lesions in man. On this basis a pilot study of a variety of skeletal lesions was made, the results of which will be presented in this communication.

THE PATIENTS

This paper is based on studies in seventy-five patients, all of whom received an intravenous or intramuscular injection of Sr^{85} or Ca^{47}, or of both. When the injection was given intravenously continuous recording over various body sites was made during the first hour or two hours after injection. From then on counting was made at irregular intervals during two to three weeks. When the isotope was given intramuscularly, counting was usually started twelve to twenty-four hours after injection. In a few patients more than one study was made (sometimes before and after treatment of a lesion).

Pertinent data of the case histories are recorded in the legends of Figures and Tables. Most of the patients were in hospital during the studies; and, in most of these, determinations on serum samples and excreta were made, the results of which will be discussed in a forthcoming publication.

ISOTOPES USED

Strontium^{85}—Sr^{85} has a half-life of sixty-five days. It decays into Rb^{85} by electron capture followed by emission of a single γ-photon (see pulse height spectrum shown in Figure 1).

Carrier-free Sr^{85} in a solution of HCl was obtained from Nuclear Science and Engineering Corporation, Pittsburg, Pennsylvania, U.S.A. The HCl solution was neutralised with Na_2CO_3, diluted with physiological saline to an activity content of 20 μC per millilitre and sterilised. Each patient was given 3 millilitres or less of this solution.

Calcium^{47}—Ca^{47} emits both β-rays and γ-rays, and has a half-life of 4·9 days. It decays into Sc^{47} which also emits β-rays and γ-rays, has a half-life of 3·8 days, and decays into Ti^{47} which is stable. The pulse height spectrum of Ca^{47}–Sc^{47} is shown in Figure 1. Ca^{47} is not yet commercially available and has not been used before in animals or man.†

* Presented in part by Dr Bauer at the UNESCO Conference on Radioisotopes, Paris, in September 1957. Submitted for publication, April 17, 1958.

† In December 1958 the International Atomic Energy Agency (IAEA) in Vienna arranged a conference for exploration of possible demand and means of production of Ca^{47}. A detailed report from this conference has been issued by IAEA.

There are at least two methods for production of Ca^{47}: 1) Neutron irradiation in the pile of enriched Ca^{46}; and 2) proton irradiation in the cyclotron of enriched Ca^{48}.

Method (1) is less advantageous than method (2), because enrichment of Ca^{46} is considerably

TABLE I

MASS ANALYSIS OF CALCIUM (per cent abundance)

	Natural material	Enriched material*	
		Harwell	Oak Ridge
Ca^{40}	96·9	79·1	82·91
Ca^{42}	0·64	0·82	0·95
Ca^{43}	0·14	0·24	0·20
Ca^{44}	2·1	9·81	5·13
Ca^{46}	0·0032	8·70	9·55
Ca^{48}	0·18	1·3	1·27

* Typical batches.

more expensive than enrichment of Ca^{48}, and because enrichment of Ca^{46} is accompanied by enrichment of Ca^{44} (Table I). Neutron bombardment of Ca^{44} in the pile gives Ca^{45} (half-life 152 days), and the Ca^{47} produced according to method (1) will therefore be contaminated with an isotope with an undesirably long half-life.

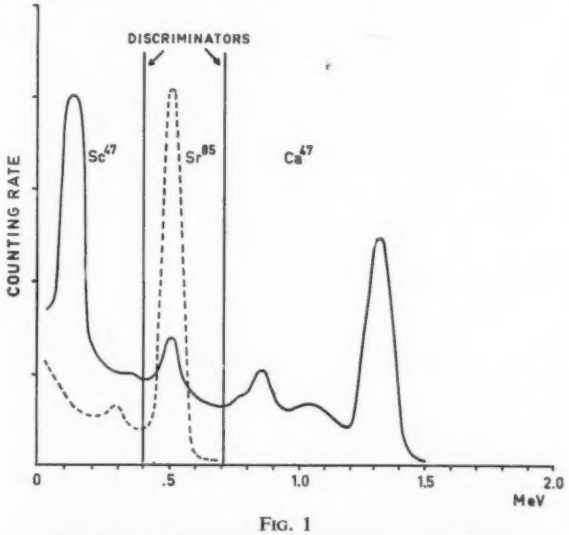

FIG. 1

Sr^{85} and Ca^{47}–Sc^{47} gamma-ray pulse height spectra. The gamma energies recorded on the abscissa are directly proportional to the pulse heights. The two main discriminator settings used in this study have been indicated on the graph.

However, it has so far proved difficult to obtain useful facilities for cyclotron production of Ca^{47}, and therefore method (1) was used. One milligram of Ca^{46} was obtained from the Atomic Energy Research Establishment, England, and taken to the Idaho Falls Material

Testing Reactor, operated by the Phillips Petroleum Company, Idaho Falls, Idaho, U.S.A. The sample was irradiated for six days at a flux of about 10^{14} neutrons/centimetre^2/second. At the time of removal from the pile the estimated Ca^{47} content was 600 μC, and the Ca^{45} content was about 70 μC. The sample was taken by air to Sweden, dissolved in HNO_3, brought to just below neutral with Na_2CO_3, diluted with physiological saline to about 60 μC per millilitre, and sterilised. The patients received 1 millilitre or less of this solution. About one half-life elapsed from removal of the Ca^{47} from the pile to the administration of the isotope to the first patient. Because of contamination with Ca^{45}, Ca^{47} is at present not given to children.

Of three batches of Ca^{47} used, two have been produced as described above, and one has been produced by irradiation in the DIDO reactor at the Atomic Energy Research Establishment, Harwell, England. It should be pointed out, also, that at Oak Ridge enriched Ca^{46} is available in greater abundance and with a lower relative Ca^{44} content. This material is more expensive, however. With the procedure described above, the cost for the Ca^{47} at the time of injection of the first patient has been about $3·00 per μC. It seems reasonable to assume that this cost will be reduced if the demand increases so that Ca^{47} can be produced on a routine basis.

TABLE II

ABSORBED RADIATION DOSE

Isotope	Dose (*μC/kilograms body weight*)	Critical organ	Total absorbed radiation dose (*rads*)	Weekly exposure (*rads*)
Ca^{45}	0·1	Bone	5·6	$<$0·3
Ca^{47}	1·0	Bone	4·4	0·3
Sr^{85}	1·0	Bone	3·4	$<$0·3
I^{131}	0·3	Thyroid	35	$>$0·3

The data in this Table are necessarily approximate and refer to intravenous administration in a 70-kilogram man.

RADIATION HAZARDS

In conditions involving *persistent exposure* to ionising radiations, the International Commission on Radiological Protection has recommended that the dose received shall not exceed 0·3 rad weekly, averaged over any period of thirteen consecutive weeks. The magnitude of this dose is "such as to involve a risk which is small compared to the other hazards of life." The 0·3 rad dose may therefore be exceeded 1) if the subject will not be persistently exposed, or 2) if the dose given will be of diagnostic or therapeutic value. On the basis of the approximate radiation dose values given in Table II we therefore feel safe with the dosage used in this investigation. It should perhaps be emphasised that the amount of isotope given in each case has been decided on the merits of the status of the individual (such as age), and has been kept at the least that still gives reasonably good counting conditions.

For comparison the radiation dose delivered from I^{131} when used for a diagnostic thyroid uptake study has been entered in Table II. For a thorough discussion of practical aspects of radiation hazards involved in use of radioactive isotopes for medical purposes, the reader should consult the excellent monograph by Veall and Vetter (1958).

COUNTING EQUIPMENT

Scintillation detector—An EKCO scintillation detector, type N559A, with a 1·5 inch by 1·0 inch Na(T1)I crystal, type EKCO N556, was mounted in an LKB clinical collimation head, type 3370. The latter could be fitted with various convertible lead collimator inserts which permitted a definition of the sensitive area as shown in Figures 2 and 3. Usually the 34 degrees

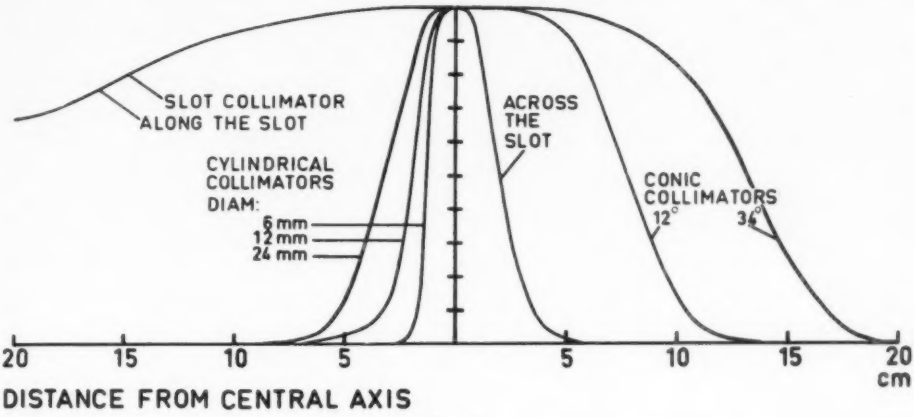

FIG. 2

Sensitivity curves for different collimators. In the graph are recorded the relative counting rates when a small source of Sr^{85} was moved on a plane at right angles to the central axis of the crystal. The crystal-to-source distance along this axis was 30 centimetres.

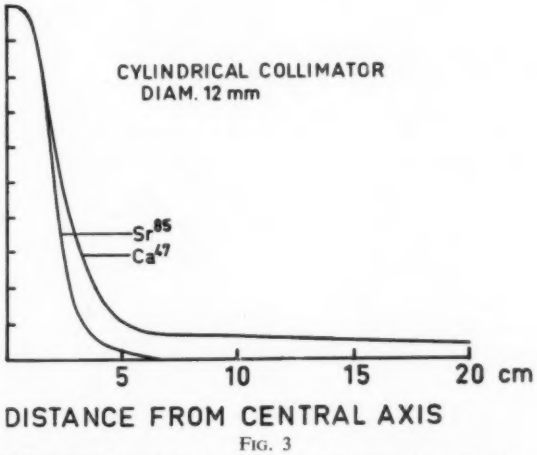

FIG. 3

Ca^{47} and Sr^{85} sensitivity curves for the 12-millimetre collimator. Note the sharper delineation of the Sr^{85} counting area.

or 12 degrees wide angle was used. When higher resolution was necessary, the 24-millimetre cylindrical, or the 10-millimetre slot aperture insert was used.

The lead thickness at the level of the crystal was about 45 millimetres, increasing to 180 millimetres around the aperture when the narrow collimator inserts were used. The height of the collimation head was such that less than 5 per cent of total background radiation could enter the crystal from a direction opposite to the counting aperture.

Pulse height analysis—The pulses from the photomultiplier tube were magnified in an EKCO linear amplifier, type N568, and fed into the scaler or ratemeter via a Dynatron single channel pulse analyser, type N101. With only two discriminator settings on this latter instrument the radiation emanating from the Sr^{85} and the Ca^{47} could be individually analysed (Fig. 1). At the lower of these settings both Ca^{47} and Sr^{85} were counted. At the upper of these settings no Sr^{85} and approximately 50 per cent of the Ca^{47} was counted. By counting standard samples before and after each patient measurement, the Ca^{47} high/low discriminator counting rate factor was checked. Work is in progress to study more closely the pulse height spectra obtained from Ca^{47} and Sr^{85} when counting over different body regions.

As a check on the stability of the counting device, continuous scanning of the γ-radiation pulse height spectrum was made with a Na^{22} standard sample. This spectrum has two peaks, one at 0·51 MeV, and another at 1·28 MeV. The lower of these peaks coincides with the 0·51 MeV peak of Sr^{85}, and the higher with the 1·3 MeV peak of Ca^{47}. Scanning of the Na^{22} in addition to the Ca^{47} and Sr^{85} spectra therefore permitted checks on the stability in the position of these peaks.

Recording device—Usually the counts were recorded on an EKCO scaler, type N530. Continuous recording was made with an EKCO ratemeter, type N522, attached to a Speedomax recorder.

Body surface counting—The detector was usually placed with the outer aperture of the collimator situated close to the skin of the area to be counted. The crystal-to-skin distance then was about 15 centimetres. When the slot collimator insert was used it was placed at a crystal-to-table distance of 30 centimetres. The patient was usually in the supine position.

When the measurements were made over the limbs, corresponding sites on the right and left sides were always counted in order to permit comparison of a diseased region with a normal region. Unless these locations have been indicated in the figures, the *thigh* means a location 20 centimetres proximal to the base of the patella, the *knee* was counted with the aperture of the counter centred over the patella, and the *tibia* means a site 25 centimetres distal to the apex of the patella.

In addition to these standard sites other areas were counted as indicated by localised lesions. Positioning of the counter over such lesions was made with the aid of radiographs and palpation, and the skin was marked with a wax pencil in order to ensure correct repositioning. In certain cases scanning of an entire region was made with the counter narrowly collimated.

On each occasion at each site two measurements were always made with repositioning of the counter between measurements in order to reduce as far as possible the error introduced by faulty positioning. One thousand counts or more were always recorded. The counting rates obtained were corrected for background which was always counted for 10,000 counts. The counting rates of standard samples of Ca^{47} and Sr^{85}, respectively, were simultaneously measured at standard conditions. The body surface counting rates were expressed as percentages of these standard counting rates, and were thus corrected for decay. It should perhaps be emphasised that the body surface counting rates usually cannot be directly compared between patients because of difference in dosage, geometry, or excretion.

It should be realised that accurate positioning of the counter requires some skill, and furthermore that small lesions and narrow collimators tend to increase any error caused by malposition of the counter. In general, however, this error was small. Thus, in fifty different double measurements of the knee region in five patients with normal knees (Table III) the percentage deviation of a single observation from the mean of the two recorded was 2·6 per cent $\pm$0·09. Repositioning thus did not introduce any appreciable error, the standard deviation due to the random nature of radioactive decay being 3 per cent or less.

RESULTS*

Normal tissue—After intravenous injection of Sr^{85} the counting rate over the normal thigh rises to a peak in a few minutes and then gradually declines during a one-to-two-week experimental period. The counting rate over the normal knee does not reach a peak until

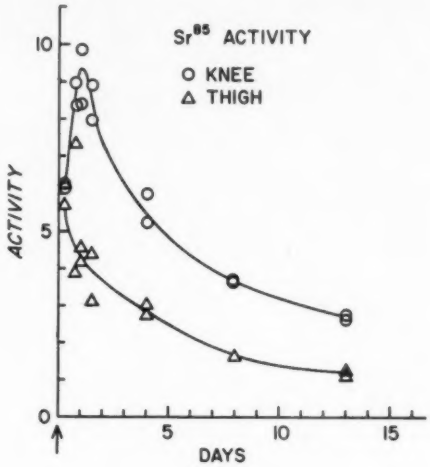

FIG. 4

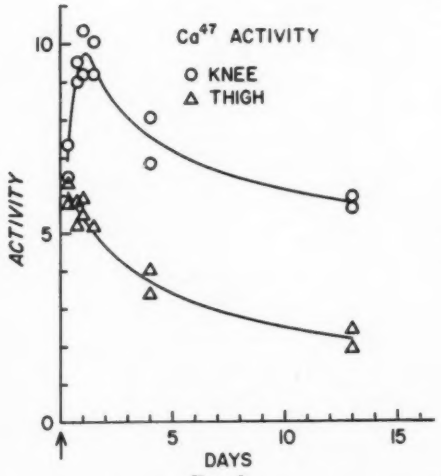

FIG. 5

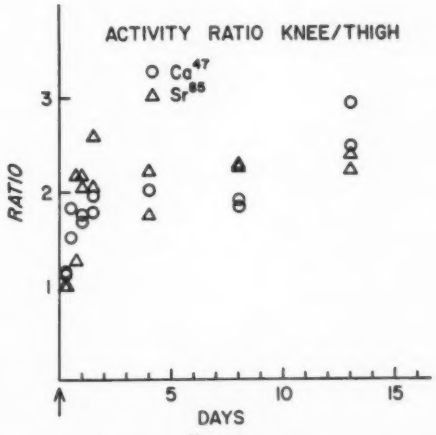

FIG. 6

Case 1—Man aged fifty with clinically normal skeletal metabolism, who received 30 μC Ca^{47} and 40 μC Sr^{85} by simultaneous intravenous injection. External Sr^{85} (Fig. 4) and Ca^{47} (Fig. 5) counting rates were recorded over the knee and thigh. Note that the knee peak was reached at about the same interval for both isotopes. The decline in knee and thigh activity was more rapid for Sr^{85} than for Ca^{47}. The knee/thigh activity ratio (Fig. 6) was about the same for both isotopes.

after about twenty-four hours (Fig. 4). In an earlier communication (Bauer and Ray 1958) this finding was explained by the fact that equilibration between serum and other body fluid strontium is faster than that between serum and exchangeable bone strontium. The peak of

* Pertinent technical details concerning the individual measurements discussed in this paper have been summarised in Table V.

activity over the thigh is thus reached earlier than that over the knee because the scintillation counter over the thigh " sees " proportionately more soft tissue than that over the knee.

In the same case the Ca^{47} thigh and knee peaks were reached at about the same intervals

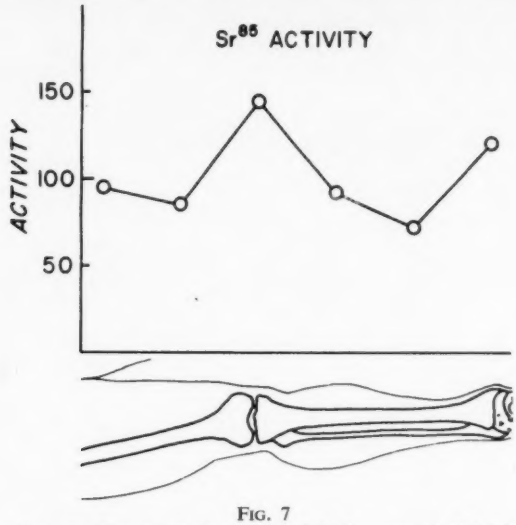

FIG. 7

Case 2—Boy aged nine with clinically normal skeletal metabolism, who received 20 μC Sr^{85} by intravenous injection. External activities were recorded over the legs twelve days after injection. The 34° collimator was used. The activity (in arbitrary units) has been plotted on the ordinate against the location of the counter on the abscissa. Note relatively high uptake over metaphysial bone.

after injection as the corresponding Sr^{85} peaks (Fig. 5). The subsequent decline in Sr^{85} activity occurred at a faster rate than that in Ca^{47} activity. This is explained by the preferential excretion of Sr; in this case the one-week Sr and Ca excretion values thus were 55 per cent and 34 per

TABLE III

EXTERNAL COUNTING RATE RATIOS IN CLINICALLY NORMAL KNEES

Case	Isotope	Right/left knee ratio ±S.D.
16	Ca^{47}	0·99±0·004
21	Ca^{47}	1·04±0·008
17	Sr^{85}	0·93±0·015
18	Sr^{85}.	1·02±0·039
19	Sr^{85}	1·06±0·024

The data in each patient are based on double recordings obtained at five different intervals ranging from two to eleven days after isotope administration.

cent respectively. The specific activity of the exchangeable strontium space therefore decreased at a more rapid rate than did that of the exchangeable calcium space.

However, the knee/thigh counting rate ratios were about the same for both isotopes (Fig. 6). This supports the view (Bauer, Carlsson and Lindquist 1958) that the skeleton does

not distinguish between calcium and strontium (in trace amounts). Unless specially indicated, the results obtained from external counting over various lesions after injection of Ca^{47} or Sr^{85} will therefore be discussed below without distinction between the two isotopes.

The counting rates observed over normal bone in a child are recorded in Figure 7.

The results will normally be reported in terms of the ratio of the counting rate at the pathological region to that at the normal region. In each case, when only one such ratio is reported, it refers (unless stated otherwise) to an interval after isotope injection of between six and fourteen days.

It has been our experience that the right/left counting rate ratio differs significantly from unity only in pathological conditions. Table III shows the knee ratios in five patients picked at random from those who did not have any known pathological condition in these regions.

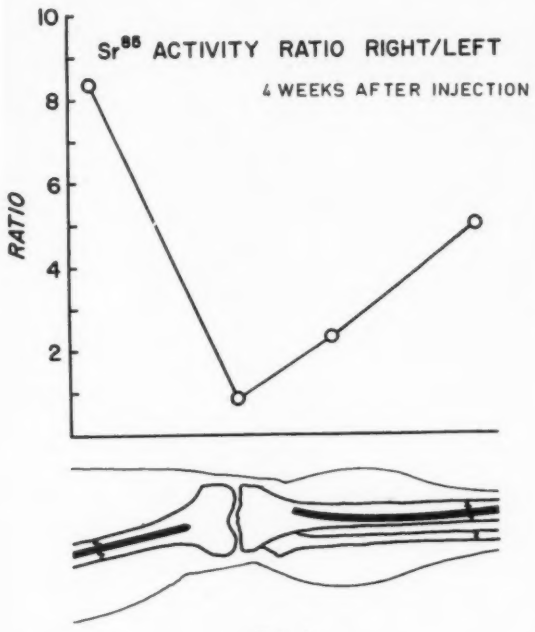

FIG. 8

FIG. 9

FIG. 10

Case 3—Youth aged seventeen, who had suffered transverse fractures of his right femur and tibia in an accident two months before the investigation. Both fractures were reduced and immobilised by intramedullary nails, which were inserted six weeks before the investigation. The patient received 20 μC Sr^{85} by intravenous injection. The 34° collimator was used. Figures 9 and 10 show radiographs of the fractures after nail fixation.

An external counting rate ratio of 1·1 thus need not necessarily mean anything abnormal, but time and again careful scanning with a narrow aperture over such areas has disclosed definitely pathological conditions.

Fractures—The counting rate over fractured bone was uniformly higher than over corresponding normal bone. Thus, in the fracture cases illustrated in Figures 8 and 11 the external counting rate ratios fractured/normal bone were about 5, 8 and 12. These ratios always increased with time even after the initial one or three days of activity equilibration within the exchangeable calcium (strontium) space. The interpretation of this observation will be discussed below.

It was always found that narrowing of the counter aperture gave a higher ratio when fractures and other relatively sharply defined lesions were counted. The obvious reason for this is that with a narrow aperture, the counter " sees " relatively more bone of a higher

isotope content than that of adjacent more normal bone. In general it was considered, however, that the use of too narrow an aperture would be less informative for two reasons: accurate localisation is difficult when the area to be counted is small; a small area might be difficult to define in morphological terms (indeed in any terms if the reduction of the volume counted is carried *ad absurdum*—one Ca^{47} atom as compared to a Ca^{40} atom). Usually the 12 degrees collimator was therefore used.

The importance of the choice in definition of the counting area is particularly evident in the cases of intracapsular fracture of the femoral neck. The femoral neck and head normally

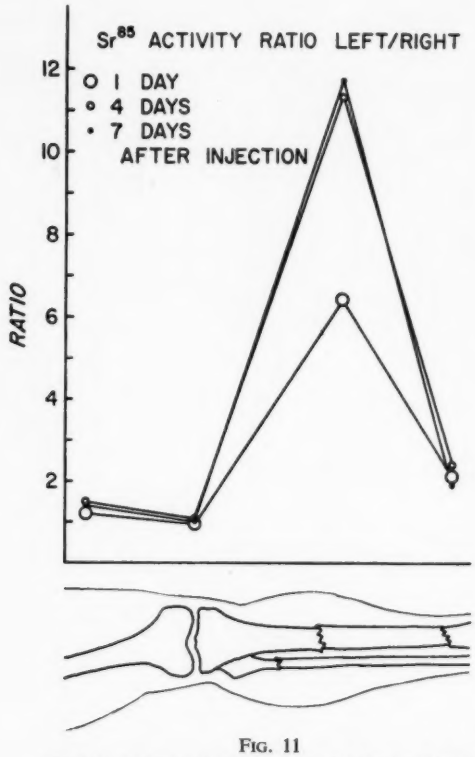

FIG. 11

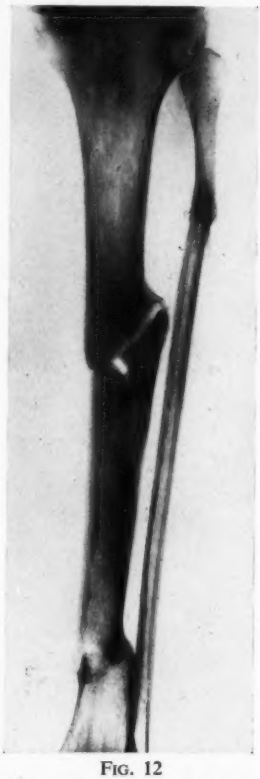

FIG. 12

Case 4—Man aged twenty-seven, who had suffered two transverse fractures of his left tibia in a motor accident twelve months before the investigation. The fractures were immediately reduced and immobilised by an intramedullary nail. Three months before the investigation the fractures were clinically solid and the nail was removed. The patient received 40 μC Sr^{85} by intramuscular injection. The 12° collimator was used. Figure 12 shows a radiograph of the limb.

exhibit a relatively low isotope uptake as compared to the surrounding pelvic bone. Even if the neck isotope uptake is increased by fracture, the external counting rate ratio fractured/normal hip may be only slightly higher than unity if measured with a large (12 degrees) counter aperture. When the hip area is scanned with a 24-millimetre aperture a higher ratio will be obtained, as illustrated in Figure 19.

It is obvious that the external counting rate ratio fractured/normal should vary with the delay between fracture and investigation. In mature rats, for instance, the twenty-four-hour activity uptake in a femoral shaft fracture peaks at about one to two weeks after fracture

(Bauer 1954). In man this problem can be studied by repeated investigations in one and the same individual, or by comparison of uptake studies in different individuals. In a preliminary study on these lines seven cases of intracapsular fracture of the femoral neck due to non-malignant disease were investigated under reasonably identical conditions. These cases have been grouped in Table IV according to the interval between fracture and isotope investigation. It is seen that the external counting rate ratios tend to increase during the initial six or eight weeks after fracture, and then gradually decrease. This finding corresponds to what might be expected and to the findings in rats referred to above. However, the uniformity of the group is far from established. Future experiments and the clinical course of the patients will tell whether or not these findings are representative.

TABLE IV

FRACTURES OF THE FEMORAL NECK

Case	Age (*years*)	Isotope used	Type of fracture	Interval between fracture and investigation (*weeks*)	Ratio fractured/sound hip
19	63	Sr^{85}	Intracapsular, impacted	1	1·4
20	51	Sr^{85}	Intracapsular, nailed	2	1·1
21	72	Ca^{47}	Intracapsular, impacted	4	1·5
22	73	Ca^{47}	Intracapsular, impacted	5	1·9
23	73	Sr^{85}	Intracapsular, nailed	5	2·1
24*	76	Sr^{85}	Intracapsular, nailed	6	3·3
24*	76	Ca^{47}	Intracapsular, nailed	6	2·7
20	51	Sr^{85}	Intracapsular, nailed	15	2·0
25	48	Sr^{85}	Intracapsular, nailed	17	1·9
26	50	Sr^{85}	Pertrochanteric	6	6·3

* Simultaneous administration of Sr^{85} and Ca^{47}.

Ratios fractured/sound hip ten days after isotope injection in seven cases with intracapsular fractures of the femoral neck and one case with a pertrochanteric fracture of the femur. The cases are grouped according to the interval between fracture and isotope investigation. The patients received 30–50 μC Sr^{85} and/or Ca^{47} by intramuscular or intravenous injection. The 12° collimator was used in all cases.

The one patient with pertrochanteric fracture of the femur had a higher external counting rate ratio than the intracapsular fractures (Table IV). This might be explained by the different type of bone in the trochanteric region and possibly also from a lesser " contamination " with isotope " seen " in surrounding bone.

One patient with a nailed intracapsular femoral neck fracture (Case 27) died three weeks after Sr^{85} injection. Her femur was removed at necropsy and external counting was made over the femoral neck both with the nail *in situ* and after removal of the nail. Identical counting rates were obtained. The possible effect of an intramedullary nail and other osteosynthetic material on the external counting rate will need further study.

In the single case of delayed healing studied (Figs. 13 and 14) the external counting rate ratio fracture/normal was 10, with a wide (12 degrees) aperture, and 24 with a narrow (10-millimetre slot) aperture.

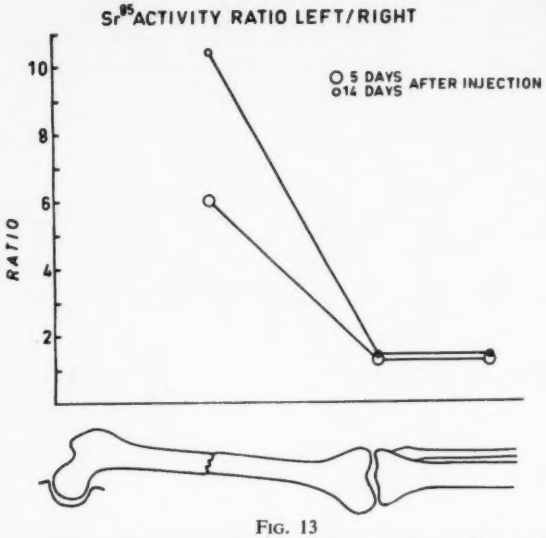

FIG. 13

FIG. 14

Case 5—Woman aged forty-six, who two years before the isotope investigation suffered a fracture of her left femur in an accident. The fracture was reduced and immobilised by an intramedullary nail. During the first one and a half years evidence of delayed healing developed, and the nail was extracted. At the time of the investigation the fracture was uniting. The patient received 20 μC Sr^{85} by intramuscular injection. The 12° collimator was used. Figure 14 shows a radiograph of the femur after the nail had been removed.

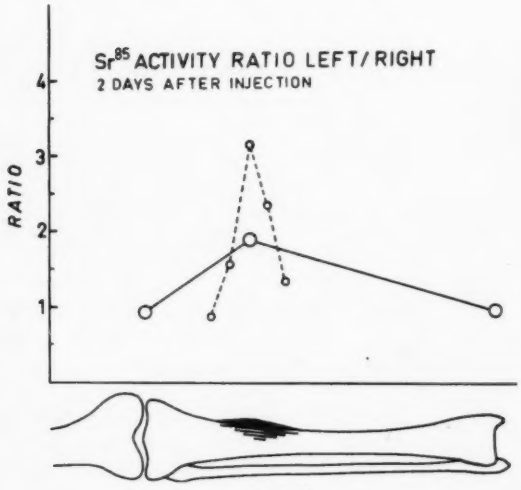

FIG. 15

FIG. 16

Case 6—Boy aged five who had a "periosteal reaction" in the proximal part of his right tibia. The patient received 10 μC Sr^{85} by intramuscular injection. The 12° (solid line) and 24-millimetre (broken line) collimators were used. Figure 16 shows a radiograph of the tibia.

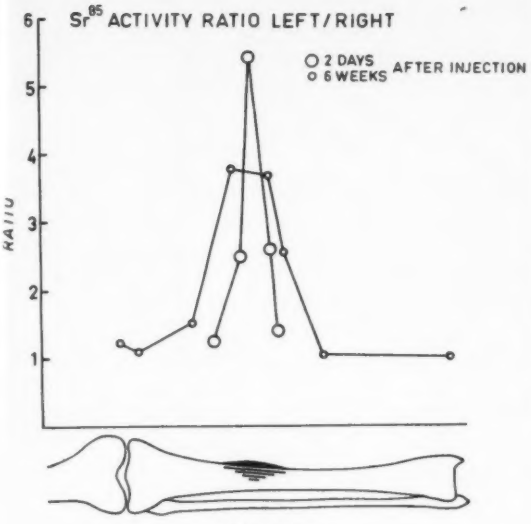

FIG. 17

FIG. 18

Case 7—Boy aged ten, who had a " periosteal reaction " in the proximal part of his right tibia. The patient received 10 μC Sr^{85} by intramuscular injection. The 24-millimetre collimator was used. A radiograph of the lesion is shown in Figure 18.

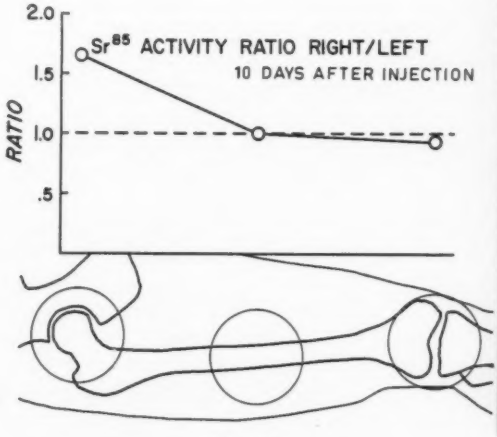

FIG. 19

FIG. 20

Case 8—Woman aged fifty-seven who had an intracapsular fracture of her right femoral neck. See text under *Fractures*. The patient received 45 μC Sr^{85} by intramuscular injection. The 12° collimator was used (Fig. 19). The amount of tissue " seen " by the counter has been roughly indicated in this figure. Scanning of the right and left hip regions was made with the 24-millimetre collimator. Lead markers were placed over the sites with the highest ratios fractured/sound hip. The radiograph in Figure 20 was subsequently made. Note the faint fracture line transecting the femoral neck exactly in line with two of the markers. These markers corresponded to the two highest ratios (4·3 and 3·5).

The two cases illustrated in Figures 15 to 18 were alike in so far as they concerned young boys, each of whom had a " periosteal reaction " of one tibia, barely seen in radiographs. Possibly these " reactions " were caused by tiny fractures of the tibiae, even though the case histories did not support this. In both cases the external counting rates over the lesions were increased over normal by factors of about 4.

The patient in Case 8 (Figs. 19 and 20) was referred for orthopaedic consultation because of persistent pain in the right hip. The history did not reveal any accident. Physical examination disclosed a pelvic dip to the left when the patient lifted her left foot off the ground, and slightly painful rotational movements in her right hip. The radiograph did not show any abnormality in this region. However, as illustrated in Figure 19, the external counting rate ratio right/left hip was slightly elevated as measured with a wide aperture (12 degrees) counter. Careful scanning of the hip regions with a narrow aperture (24 millimetres) disclosed three locations where the ratios right/left were as high as 4·3, 3·5 and 2·4 respectively. These locations were marked with lead markers, and the radiograph illustrated in Figure 20 was made. It is seen that a faint fracture line transects the femoral neck exactly in line with two of the markers. These two markers corresponded to the two highest ratios of the three recorded above. (As for the genesis of this comparatively rare fracture considerable speculation has arisen. The patient had had an operation for a cancer of the uterus and had received a large dose of therapeutic radiation to her pelvis. The fracture might have been due to radiation damage or to a cancer metastasis. The clinical course of the patient has been uneventful during the year since the investigation.) This case emphasises that the external counting technique may detect skeletal lesions before they are visible in radiographs. This will be referred to again later.

Slipped upper femoral epiphysis—Three one-sided cases of this disease have been studied with external counting after administration of Sr^{85}. In two cases the epiphysial line was not closed, and lesion/normal external counting rate ratios of unity were observed. In one case the epiphysial line appeared to be closed, and the external counting rate ratio lesion/normal was 0·74. The fact that this ratio was below unity was considered to strengthen the clinical conclusion that the patient could be allowed to bear weight on his hip.

Bone tumour—All patients with malignant or benign tumours hitherto investigated have exhibited a higher Ca^{47} or Sr^{85} uptake in the tumour area than in normal bone (Figs. 21 to 28). The external counting rate ratios sometimes were exceedingly high, as over a chondroma of a femoral shaft (Fig. 21) and over an eosinophilic granuloma of a tibia (Fig. 23) where the 12 degrees collimator determined ratios were above 10. The bone cyst (Figs. 25 and 26), on the other hand, had an external counting rate ratio lesion/normal of only 2·0, but here the bone of the cyst wall was very thin. The specific activity (labelled/non-labelled bone) of the lesion probably was considerably higher than on the normal side.

In the patient with a chondroma (Figs. 21 and 22) uptake studies were made before, during and after radiotherapy of the lesion. Almost identical results were obtained in the three studies. Whereas this investigation confirms the accuracy of localisation of the lesion by means of this technique, it is perhaps surprising that the numerical values of the ratios were so uniform. One might speculate that the trauma caused by curetting out the lesion counteracted a possible effect on the uptake caused by therapeutic x-rays. Work is in progress to study the effect of therapeutic x-rays in a further series of patients with primary and secondary lesions of bone caused by malignant tumour.

It already seems certain that the external counting technique as used in this laboratory definitely aids the localisation and delineation of bone tumour (Figs. 27 and 28). Another example of this is furnished by a patient (Case 28) in whom a radiograph showed signs of metastatic cancer in the eleventh thoracic and third lumbar vertebral bodies. External counting showed peak values not only over these vertebrae but also over the fifth lumbar vertebra. Subsequent radiographs indicated that this vertebra also had fractured because of metastatic cancer.

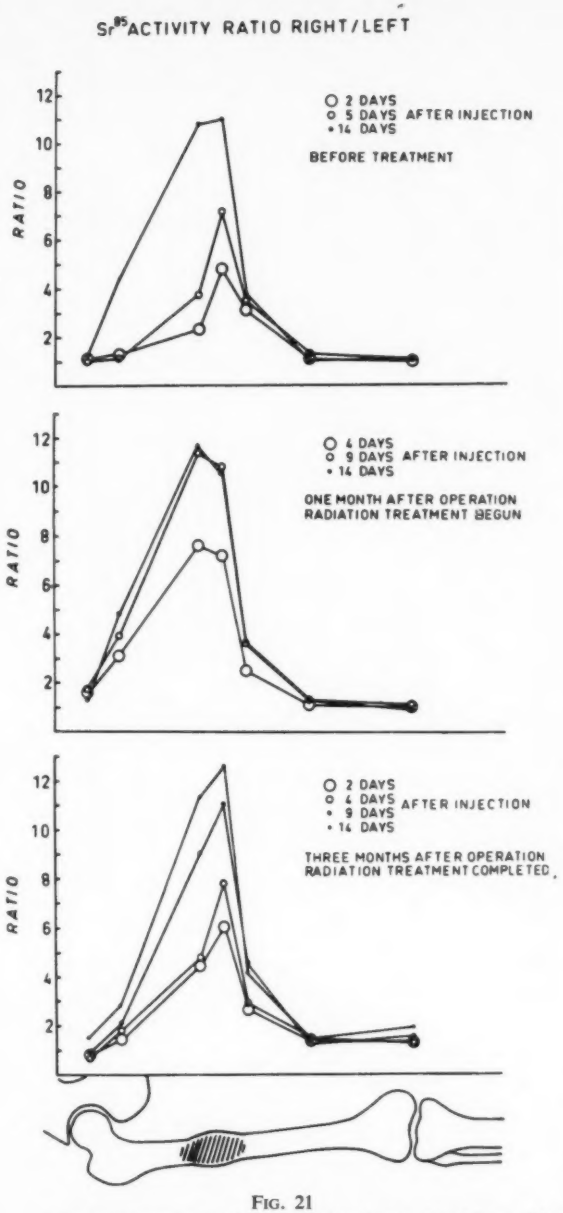

FIG. 21

FIG. 22

Case 9—Woman aged fifty-seven who had a chondroma of her right femur. The tumour was removed by curetting, and radiotherapy was given after operation. Isotope investigations were made before, during and after treatment. At each investigation the patient received 40–50 μC Sr^{85} by intramuscular injection. The 12° collimator was used. Before each new investigation the activity over both femurs was determined and these values formed the background values in the subsequent investigation. Figure 22 shows a radiograph of the affected femur.

TABLE V

TECHNICAL DATA OF EXTERNAL COUNTING RATE STUDIES

Figure	Table	Case	Isotope	Dose μC	Lesion	Interval after injection (*days*)	Collimator	Discriminator setting		Net maximal counting rate (c/s) over lesion	Background
								Lower	Upper		
4	—	1	Sr^{85}	40	Clinically normal	4	34°	10	—	25	3·2
5	—	1	Ca^{47}	30	Clinically normal	4	34°	35	—	12	1·0
7	—	2	Sr^{85}	20	Clinically normal	12	34°	10	—	18	3·2
8	—	3	Sr^{85}	20	Femoral fracture	26	34°	10	—	18	2·4
8	—	3	Sr^{85}	20	Tibial fracture	26	34°	10	—	7	2·4
11	—	4	Sr^{85}	40	Tibial fracture	7	12°	10	—	28	2·2
13	—	5	Sr^{85}	20	Femoral fracture	14	12°	15	—	17	2·7
15	—	6	Sr^{85}	10	Periosteal reaction of tibia	2 2	12° 24 mm.	15 15	— —	15 3	2·9 2·3
17	—	7	Sr^{85}	10	Periosteal reaction of tibia	2	24 mm.	15	—	5	2·2
19	—	8	Sr^{85}	45	Femoral neck fracture	10	12°	15	—	16	2·6
21	—	9	Sr^{85}	40	Chondroma of femur	14	12°	10	—	25	2·3
21	—	9	Sr^{85}	40	Chondroma of femur	14	12°	15	—	68	2·8
21	—	9	Sr^{85}	50	Chondroma of femur	14	12°	17	24·5	45	0·6
23	—	10	Sr^{85}	20	Eosinophilic granuloma of tibia	6	12°	10	—	36	2·2
25	—	11	Sr^{85}	20	Solitary bone cyst of femur	18	12°	15	—	10	2·8
27	—	12	Sr^{85}	60	Metastatic cancer of vertebral body	8	24 mm.	16	23·5	9	0·4
29 30	—	13	Ca^{47}	60	Paget's disease of tibia	13 1	34° Slot	10 15	— —	99 13	3·0 2·3
32	—	14	Sr^{85}	35	Osteomyelitis of humerus	3	24 mm.	15	—	4	2·1
34	—	15	Sr^{85}	10	Osteomyelitis of tibia	42	24 mm.	15	—	3	2·3
—	III	16	Ca^{47}	50	Clinically normal knee	2	12°	15	—	48	1·9
—	III	17	Sr^{85}	50	Clinically normal knee	2	12°	16	23·5	28	0·5
—	III	18	Sr^{85}	50	Clinically normal knee	2	12°	16	23·5	19	0·5
—	III+IV	19	Sr^{85}	50	Femoral neck fracture	10	12°	19	26·5	4	0·5
—	IV	20	Sr^{85}	25	Femoral neck fracture	10	12°	15	—	13	6·7
—	IV	20	Sr^{85}	50	Femoral neck fracture	10	12°	19	26·5	13	0·5
—	III+IV	21	Ca^{47}	50	Femoral neck fracture	10	12°	15	—	20	2·1
—	IV	22	Ca^{47}	50	Femoral neck fracture	10	12°	15	—	23	1·9
—	IV	23	Sr^{85}	30	Femoral neck fracture	10	12°	15	—	19	—

The data refer to the lesion and interval after injection stated in this Table. Comparison with the Figures allows complete information concerning all counting rates observed in this study.

TABLE V—*continued*

TECHNICAL DATA OF EXTERNAL COUNTING RATE STUDIES

Figure	Table	Case	Isotope	Dose μC	Lesion	Interval after injection (*days*)	Collimator	Discriminator setting		Net maximal counting rate (c/s) over lesion	Background
								Lower	Upper		
—	IV	24	Sr^{85}	50	Femoral neck fracture	10	12°	17	24·5	15	0·5
—	—	24	Ca^{47}	50	Femoral neck fracture	10	12°	35	—	3	0·8
—	II	25	Sr^{85}	30	Femoral neck fracture	10	12°	15	—	17	2·6
—	II	26	Sr^{85}	30	Femoral neck fracture	10	12°	15	—	22	2·5
—	—	27	Sr^{85}	50	Femoral neck fracture in metastatic cancer	10	12°	15	—	23	2·7
—	—	28	Sr^{85}	60	Metastatic cancer of vertebral bodies	3	24 mm.	16	23·5	8	0·5
—	—	29	Sr^{85}	20	Slipped upper femoral epiphysis	5	12°	15	—	11	2·9

The data refer to the lesion and interval after injection stated in this Table.

The number of cases is too small to allow any analysis of isotope uptake patterns in different types of malignant and benign bone tumours.

Paget's disease—The counting rate over the lesion in Case 13 was higher than normal by a factor of about six (Fig. 29). This result is in accordance with earlier findings that the overall accretion rate and the size of the exchangeable calcium space are increased in Paget's disease (Bauer, Carlsson and Lindquist 1958).

In the same patient an estimate of the blood volume in the affected tibia was made with the aid of external counting after an intravenous injection of $RI^{132}HSA$. An external counting rate ratio Paget lesion/normal of 1·5 was obtained, indicating that the corresponding Ca^{47} ratio of eight or higher even fourteen days after injection must be explained on the basis of Ca^{47} present in bone rather than in blood or soft tissues.

Osteomyelitis—The two cases of osteomyelitis investigated had higher counting rates over the osteomyelitic lesions than over corresponding normal bone. Thus, in Case 14 (Figs. 32 and 33) the ratio osteomyelitic/normal bone was about twelve. Case 15 showed a higher isotope uptake over the right tibia before the lesions were seen in radiographs. Later, when a large osteomyelitic lesion had developed which was visible also in radiographs the counting rate ratio osteomyelitic/normal bone was about eight (Fig. 34).

DISCUSSION

INTERPRETATION OF EXTERNAL COUNTING OF "BONE-SEEKING" ISOTOPES

Based on previous communications (Bauer, Carlsson and Lindquist 1955; Bauer and Ray 1958) on the kinetics of bone mineral, a brief presentation will be made of some factors involved in the interpretation of external counting rates observed after administration of radioactive calcium or strontium to man.

If accretion and excretion remove a and u units, respectively, of stable material at specific activity S_B from the serum compartment, B, of the exchangeable space, E, and one unit of

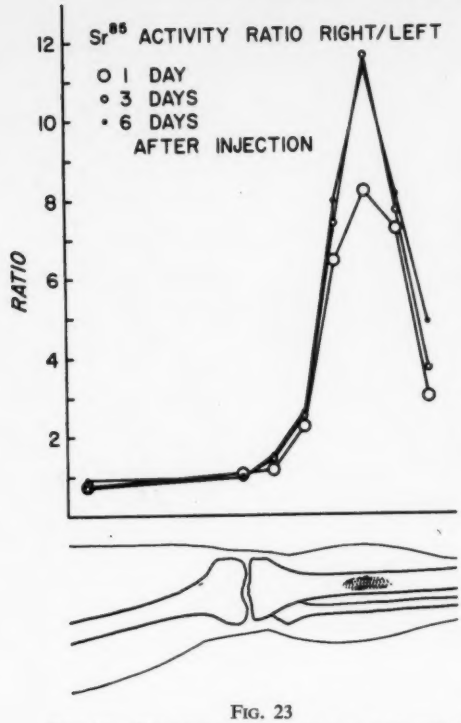

FIG. 23 FIG. 24

Case 10—Girl aged eight who had an eosinophilic granuloma in the upper part of her right tibia. The patient received 20 μC Sr^{85} simultaneously. The 12° collimator was used. A radiograph of the tibia is shown in Figure 24.

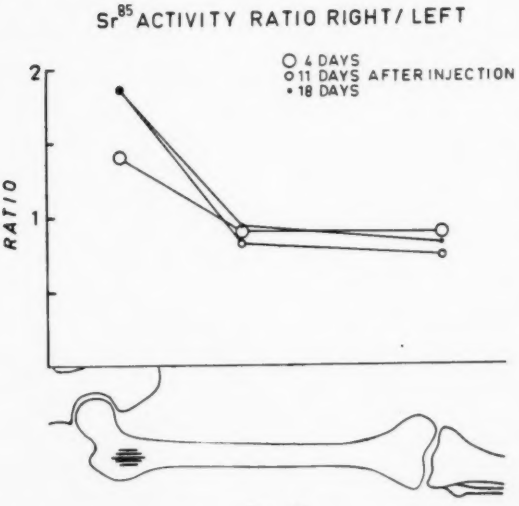

FIG. 25 FIG. 26

Case 11—Boy aged six who had a large solitary bone cyst in the proximal part of his right femur. The cyst was about 6 centimetres long and had walls about 2 millimetres thick. The patient received 20 μC Sr^{85} by intramuscular injection. The 12° collimator was used. Figure 26 shows a radiograph of the lesion.

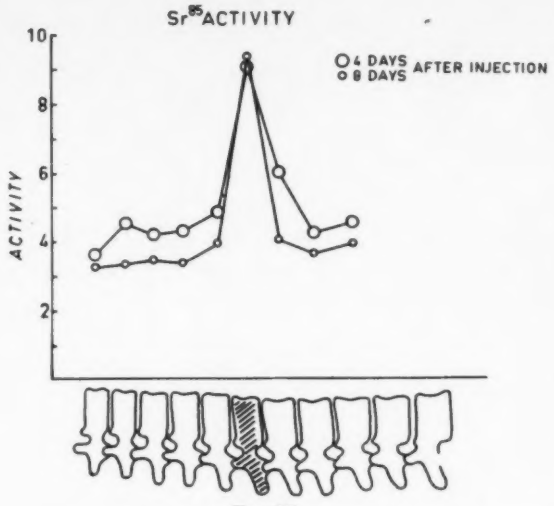

FIG. 27

FIG. 28

Case 12—Woman aged sixty-eight who was operated upon for cancer of the left breast a year before the investigation. At the time of investigation radiographs revealed a metastatic cancer in the sixth thoracic vertebral body. The patient received 60 μC Sr^{85} by intramuscular injection. The 24-millimetre collimator was used. The activity is expressed in counts per second. A radiograph of the spine is shown in Figure 28.

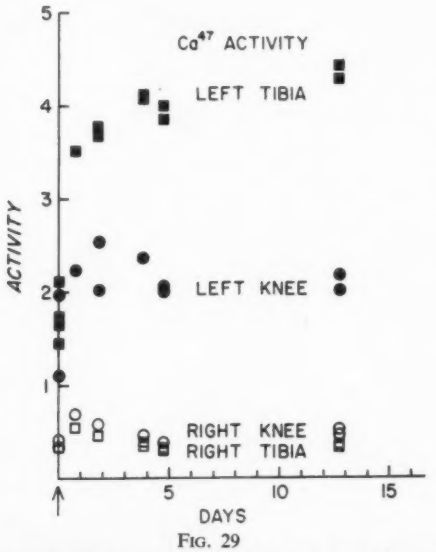

FIG. 29

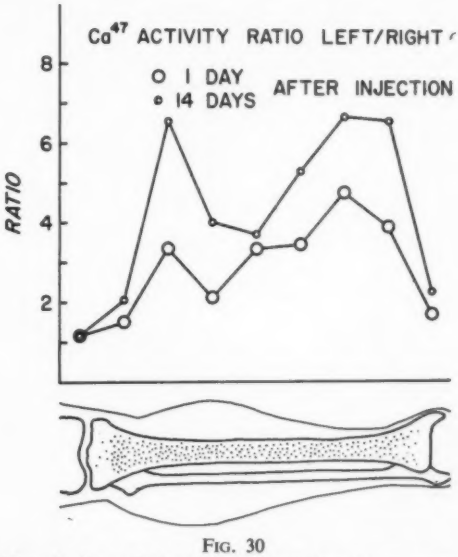

FIG. 30

Case 13—Woman aged fifty-four who had had localised Paget's disease in her left tibia for at least fifteen years. From time to time part of the lesion had been removed but it had slowly increased over the past seven years to involve most of the tibia. At the time of the investigation a prominence was felt over the lesion, and the overlying skin was warmer than over a corresponding site in her right tibia. There was no evidence of skeletal involvement other than that of her left tibia. The patient received 60 μC Ca^{47} by intravenous injection. The absolute counting rates recorded with the 34° collimator are shown in Figure 29. The counting rate ratios lesion/normal recorded with the 10-millimetre slot, fourteen days after injection, are shown in Figure 30.

activity were administered to B at zero time (t=0), then (at any interval, t, until labelled material starts to return to the exchangeable space from the non-exchangeable fraction):

$$1=E_t^*+(a+u)\int_o^t S_B(t)dt \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

where E* means fraction of dose in E.

Under the same conditions the fraction of dose (expressed in units of activity) contained in any part, α, of the body will be

$$\alpha^*_{Abs_t}=E^*_{\alpha_t}+a_\alpha\int_o^t S_B(t)dt \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

where E_α and a_α mean the exchangeable space and the accretion rate in α.

FIG. 31
Case 13—Radiograph of the tibia showing long-established Paget's disease.

On the assumption that the external counting rate $\alpha^*_{Ext_t}$ recorded over any part, α, of the body is proportional (by a factor k) to the amount of activity contained in that part

$$\alpha^*_{Ext_t}=k\times\alpha^*_{Abs_t} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

one will obtain

$$\alpha^*_{Ext_t}=k\left(E^*_{\alpha_t}+a_\alpha\int_o^t S_B(t)dt\right). \quad . \quad . \quad . \quad . \quad . \quad . \quad (4)$$

At any interval of time, t, the ratio R_{Ext_t} of the external count rates recorded over any two parts α and β of the body will then be

$$R_{Ext_t}=\frac{\alpha^*_{Ext_t}}{\beta^*_{Ext_t}}=\frac{E^*_{\alpha_t}+a_\alpha\int_o^t S_B(t)dt}{E^*_{\beta_t}+a_\beta\int_o^t S_B(t)dt} \quad . \quad . \quad . \quad . \quad . \quad . \quad (5)$$

In agreement with earlier conclusions in rats (Bauer, Carlsson and Lindquist 1955), it is seen that at activity equilibrium in E (i.e., when $S_E=S_B$), R_{Ext_t} can be constant only if the numerical value of E_α is proportional to the numerical value of a_α. Under these conditions then, Equation (5) is simplified to

$$R_{Ext_t}=\frac{a_\alpha}{a_\beta} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (6)$$

The external counting rate ratio would thus equal the accretion rate ratio. It should be realised that this deduction is based on a series of assumptions, the validity of some of which is as yet poorly established. For example, the proportionality factor, k, in Equation (3) should be written k_α, indicating that this factor varies from one anatomical region to another. It should be realised that k_α is influenced by factors related to the amount of tissue seen by the counter, by the density of this tissue, by the distribution of isotope in this tissue, by calibration of the counting equipment, by the energy of the isotope counted. Rigorous standardisation of counting techniques tends to diminish the uncertainties involved in this type of measurement. Thus, when comparing counting rates obtained over the chest with those over the extremities the relation of Equation (6) will not obtain. In comparison of counting rates obtained over corresponding sites of the right and left extremities, however, it seems safe to assume that the k_α values do not differ much from one side to another.

As shown earlier (Bauer and Ray 1958) the assumption that at activity equilibrium $S_{E_t}=S_{B_t}$ is not correct. The equilibrium reached is a transient one as symbolised by $S_{E_t}=k\times S_{B_t}$; $k>1$. An analysis of Sr^{85} data in man indicated that the value of the proportionality factor k was about 1·2. Calcium is cleared less efficiently than strontium from

the blood by the excretion processes, however, and the factor k is therefore probably smaller in isotope experiments using calcium than in those using strontium.

The absolute magnitude of this factor becomes critical for the interpretation of R_{Ext} only if it varies from one location to another. This is indeed the case; the reason why the R_{Ext}-value of the knee/thigh rises during the early intervals after intravenous injection of Sr^{85} or Ca^{47} implies that this factor is higher for the knee than for the thigh. In one and the same location this factor varies with time, however, and at activity (transient) equilibrium most of the activity located in E is located in bone (simply because 50 per cent of E is exchangeable bone with a relatively high k-value). It should further be realised that the

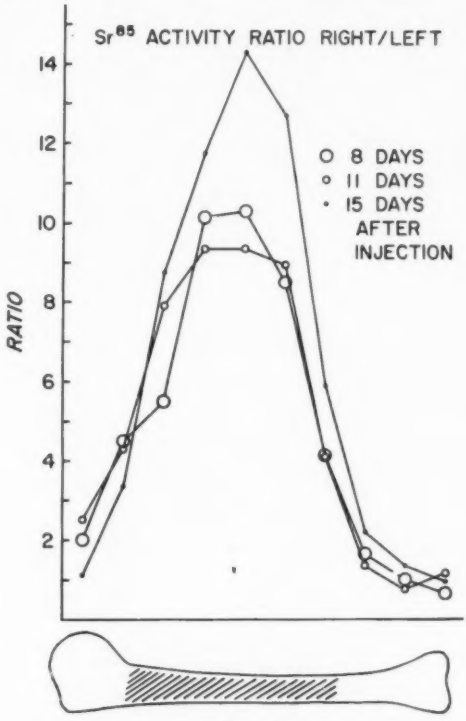

FIG. 32

FIG. 33

Case 14—Man aged twenty-nine with an acute exacerbation of chronic osteomyelitis in the right humerus. Radiographs showed extensive destruction in the middle part of the humerus. The patient received 35 μC Sr^{85} by intramuscular injection. The 24-millimetre collimator was used. A radiograph of the affected humerus is shown in Figure 33.

uncertainty in the $R_{Ext}(t)$-value introduced by variations in this k-value tends to diminish with time (because E^* decreases with time and $a\int_o^t S_B(t)dt$ increases with time). This probably explains why the R_{Ext}-values of fractured/normal bone increase with time even after equilibration within E has been reached: even though E increases when a increases, there is no strict proportionality in this relation. It has thus been found that a tenfold increase in the accretion rate is accompanied by only a three- to five-fold increase in the magnitude of the exchangeable space (Bauer, Carlsson and Lindquist 1958). In agreement with this finding the R_{Ext}-values of fracture/normal, tumour/normal and Paget/normal bone showed a continuous rise over at least fourteen days after injection of Sr^{85} or Ca^{47}.

For the sake of completeness it should finally be mentioned that the expression, $\int_0^t S_B(t)dt$, in all probability does not vary significantly from one gross area to another in bone.

A closer analysis of the factors mentioned above must await further experimentation. Judged from previous experience, however, an analysis of external counting rates together with blood and excreta activity values should give pertinent data concerning both localised and generalised skeletal disease. It is hoped that an electronic analog computer will be useful for such work in this laboratory.

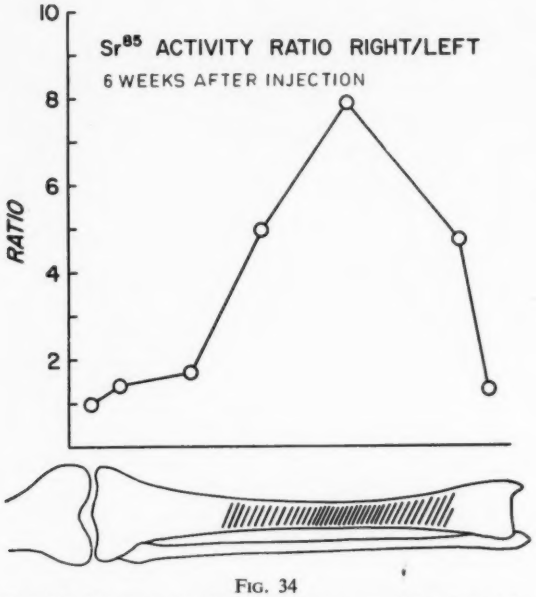

FIG. 34

Case 15—Boy aged six with suspected osteomyelitis of the right tibia despite absence of radiographic evidence of skeletal lesion. The patient received 10 μC Sr^{85} by intramuscular injection. Scanning with the slot collimator over his tibiae showed five times higher isotope uptake over the right tibia than over the left. Later, extensive osteomyelitis developed. About a month after the first isotope investigation the patient received another 10 μC Sr^{85} and counting was performed as recorded here. The 24-millimetre collimator was used.

EXTERNAL COUNTING OF OTHER "BONE-SEEKING" ISOTOPES

Radiosodium—Miller, Munro, Renschler and Wilson (1954) made a study of external counting over the knee after injection of Na^{22} or Na^{24} in man. They described some basic concepts of such a method, and showed how counting over bone demonstrates the relatively slow exchange rates involved in the soft tissue to bone sodium equilibration. Radiosodium is not suitable for studies of bone metabolism in general, however, because the ratio exchangeable/non-exchangeable sodium in the body is high as compared to the corresponding calcium ratio.

Radiogallium—Several reports on the use of radiogallium for external counting of skeletal lesions have been published. A main disadvantage of this element seems to be that it does not concentrate sufficiently in bone. In a series of twenty-four measurements of the external counting rate over femur, tibia and ulna fractures after injection of Ga^{72} the ratios

fractured/normal were higher than 2·0 only three times and never higher than 2·8. In sixty-seven cases of Ga^{72} localisation studies in cases of malignant lesions, the results were considered questionable or subsequently found false in thirty-one cases (Dudley, Markowitz and Mitchell 1956). Van der Werff (1954) obtained even less favourable results. Judging from Desgrez, Guérin and Guérin's (1958) reports of considerably better results it is possible, however, that part of the difficulties encountered with gallium is attributable to the methods of detection.

Radiobarium—Investigations on the metabolism of Ba^{140} in man indicate that barium is handled by the skeleton in about the same way as are calcium and strontium (Bauer, Carlsson and Lindquist 1958). Ba^{140} (γ-emitter, half-life 12·8 days) might therefore be used for external counting studies over the skeleton.*

SIGNIFICANCE OF EXTERNAL COUNTING OF "BONE-SEEKING" ISOTOPES

The present study suggests that external counting of Ca^{47} and Sr^{85} can be used for 1) localisation and delineation of skeletal lesions, and 2) quantitation of the accretion rate of normal bone or bone lesions. Judged from a presidential address in the Radiation Research Society, the objective under (1) is sufficient evidence that such methods have a clinical application: " At a more clinical level, we most urgently need to devise new techniques for more precise delineation of the extent of tumour spread, and for discovering the existence and localisation of metastases " (Kaplan 1957).

Usefulness of the possibility under (2) is perhaps less evident. However, there is considerable evidence from animal experiments that isotope techniques similarly used have been instrumental for a better insight into normal processes like bone growth and repair, and pathological conditions like vitamin D deficiency and protein deficiency (Bauer, Carlsson and Lindquist: in the press). Experience from animal work shows, however, that caution must be exercised not to interpret, for example, a high external counting rate ratio fracture/normal as directly indicating a high rate of fracture healing. If that of resorption proceeds at a rate equal to accretion no healing will ensue. Actually one of the highest external counting rate ratios observed in this study was in the case of delayed healing of a femur in a forty-six-year-old woman (Fig. 13).

There seem to be few theoretical or practical obstacles to extending the techniques for determination of *relative* accretion rates to yield also *absolute* accretion rates. Preliminary studies suggest that a geometry such as that used by Karpeles and Huff (1955) in their leg blood volume measurements will give data from which the accretion rate of an entire lower leg can be calculated (expressed in terms of, e.g., gram calcium per day). It seems probable, however, that for many practical purposes relative accretion rate data will be sufficient.

An estimate of the accretion rate should make it possible to estimate also the *resorption* rate because a change in bone salt content occurs at a rate equal to the difference between the accretion and the resorption rates. It is this change in bone salt content which is the basis for most diagnostic x-ray work. A change in bone salt content is, however, hard to evaluate quantitatively in man. Recent data suggest that even at favourable conditions a 30 per cent decrease in bone salt content may escape notice when present-day radiographic techniques are used (Snapper 1957).

Determinations of the bone salt resorption rate in localised lesions in man will, therefore, have to be postponed until radiographic or other techniques for bone density measurements have been improved.

In selected cases, however, sampling of bone may give also resorption rate data. Chances seem slight that the isotope technique alone can give such information.

* *Note added in proof.* It has recently been shown that Ba^{140} accumulated in normal and fractured bone in rabbits can be traced by external counting techniques (Norman S. MacDonald (1958): Kinetic Studies of Skeletal Metabolism by External Counting of Injected Radioisotopes: The Radioisotope Osteogram. The Journal of Laboratory and Clinical Medicine, **52**, 541).

SUMMARY

1. Based on studies in seventy-five patients, a technique is described for body surface activity measurements over localised skeletal lesions up to one month after injection of the γ-emitting isotopes Ca^{47} and Sr^{85}.

2. The activity was high over skeletal lesions like fracture, metastatic cancer, eosinophilic granuloma, chondroma, osteomyelitis and Paget's disease.

3. The high isotope uptake is interpreted as evidence of an increased rate of bone tissue turnover.

4. These findings suggest that external counting of Ca^{47} and Sr^{85} may be used for quantitation of the rate of formation of normal and pathological bone tissue. A special application would be localisation and delineation of metastatic cancer in cases where radiographic evidence is uncertain or non-existent.

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OBSERVATIONS ON THE MANIFESTATIONS OF OSTEOLATHYRISM IN THE CHICK

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The term " lathyrism " was introduced by Proust (1883) to describe a paralytic syndrome due to the consumption of peas of certain type—a disease that was recognised by Hippocrates. Recently it has become known that, while certain species of peas of the Lathyrus family can produce symptoms related to the nervous system in man, they are practically non-toxic to rats; but symptoms related to the skeleton and other mesodermic tissues (Strong 1956) can be produced by another variety, the common flowering sweat pea (Lathyrus odoratus), in these animals. The terms " lathyrism " and " odoratism " have been proposed to distinguish the two conditions (Strong 1956). More recently, Selye (1957) has used the terms " neurolathyrism " and " osteolathyrism " which have been adopted in these observations.

The literature on experimental osteolathyrism was at first descriptive and related mostly to rats (Geiger, Steenbock and Parsons 1933; Robinson and Bast 1934; Lewis and Schulert 1949; Ponseti and Shepard 1954; Menzies and Mills 1957), with short notes on mice (Lewis and Schulert 1949, Dasler 1958), chicks and frogs (Chang, Witschi and Ponseti 1955). The recent isolation and characterisation of the lathyric factor, beta (N-gamma-L-glutamyl)-aminopropionitrile (BAPN, Strong 1956), and the comparative effects of a variety of nitriles (Wawzonek, Ponseti, Shepard and Wiedenmann 1955; Ponseti, Wawzonek, Shepard, Evans and Stearns 1956; Strong 1956) have greatly increased interest in this syndrome. Inquiring into the conditioning factors on osteolathyrism, Selye and Bois (1957*a*) reported the protective effect of corticoids, and (1957*b*) the aggravating role of growth hormone.

Investigating the pathogenesis of this disease, Menzies and Mills (1957), Ponseti *et al.* (1956) and Bélanger (1958) made histochemical and autoradiographic studies of the ground substance of cartilage. Meanwhile, Selye (1957) recognised changes in the osteocytes, and Clemmons and Angevine (1957) described a series of changes in the osteoblasts, associated with multiple fractures and osteoporosis.

This report is intended to cast more light on the bone pathology in lathyrism.

MATERIAL AND TECHNIQUE

A diet consisting of one part Lathyrus odoratus seeds* finely ground and mechanically blended with an equal part of Purina growing mash was given to six male day-old chicks and six male ten-day-old chicks for seven days. Comparable controls were fed on the growing mash only. The diet was not restricted in quantity, and fresh tap water was given to drink. The chicks were kept at about 35 degrees centigrade throughout the experiment.

Some of the animals were injected with a tracer dose of $S^{35}O_4$ two hours before decapitation. The results of this have been reported elsewhere (Bélanger 1958).

The tibiae, the lower jaw and the lower half of the vertebral column including the spinal cord were fixed for forty-eight hours in a solution of one part neutral formaldehyde to three parts of 95 per cent ethanol.

Some tissues were then demineralised for one week in a solution of 5 per cent nitric acid in 70 per cent ethanol, and were then dehydrated and embedded in paraffin. Others were treated by Lillie's (1948) method of silver impregnation and embedded in celloidin. Others were embedded in celloidin without demineralisation. Sections of demineralised and

* Supplied by the Ferry-Morse Seed Company, Detroit, Michigan, United States of America.

mineralised tissues were stained with haematoxylin-phloxine B and orange G (H.P.O.), the periodic acid-leucofuchsin stain (P.A.S.) of Hotchkiss-McManus (Gomori 1952), toluidine blue (TB), the von Kossa silver nitrate method and by the ferric chloride-ferrocyanide substitution technique for calcium (McGee-Russell 1958).

Some sections were dehydrated and mounted unstained in permount for examination under polarised light and in phase contrast (Dark M, AO). The sections of material treated by the Lillie silver impregnation method were mounted without counterstain.

OBSERVATIONS

Macroscopical studies—As the experiments were originally planned, the animals were to be killed at several weekly intervals. However, the onset of symptoms was so dramatic and generalised that earlier termination was necessary.

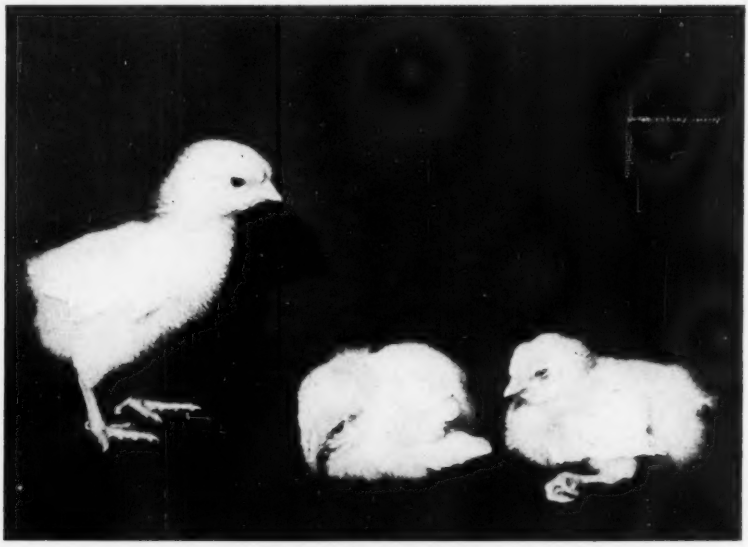

FIG. 1

On the right, two chicks after seven days on the osteolathyrogenic diet. *On the left*, a control of the same age.

The average food consumption of the experimental chicks was reduced to 85 per cent of that of the controls after two days; to 58 per cent after three days and to 45 per cent on the fourth day, remaining approximately at that level until the seventh day.

The body weight of the experimental chicks did not show a rapid change, being 95 per cent that of the controls after three days and 85 per cent at the end of the experiment.

On the fourth day the toes began to appear crooked in some chicks, the beak became asymmetrical, subcutaneous haemorrhages appeared, and the feathers on the wings became gradually ruffled and discoloured. The chicks, at first nervous and easily excited, later became sleepy and apathetic (Fig. 1).

The experiment was terminated on the seventh day because most of the birds (four in the first group and five in the second) were then unable to stand (Fig. 1) and consequently unable to feed properly. The knee joints at that stage were swollen, reddish and apparently painful to touch. The claws were clutched. The tibiae were very fragile, one at least showing a spontaneous fracture below the epiphysis.

At necropsy, the tissues of the lathyric chicks appeared considerably redder than those of the controls. One bird of the older group showed a gross deformation of the knee joint.

Microscopical studies—Among the soft tissues studied, the epidermis, the generalised connective tissue, the skeletal muscle, the aorta and the various segments of the stomach did not show any evident pathology. One seven-day-old lathyric chick showed an intrameningeal mass in the lumbar area (Fig. 3). This tumour seemed at first to consist of adipose tissue, but in the slide stained with P.A.S. it revealed a great affinity for the stain. This mass had invaded and destroyed the thoracic part of the spinal cord and could by itself explain the apparent paraplegia, as shown in Figure 1.

When sections of demineralised bones were examined after H.P.O. staining, one specimen (Fig. 2) showed that the articular portion of the tibial cartilage had become separated from the growing zone underneath by an invasion of highly vascularised, and apparently soft, connective tissue. This condition was present to a greater or lesser extent in most lathyric chicks of the two groups. The distribution of cells in the three zones of the epiphysial cartilage (the articular, small and large cells) was apparently normal, contrary to what is observed in rickets (Bélanger and Migicovsky 1958). However, the cartilaginous portions of the lumbar vertebrae were markedly deformed (Fig. 3).

The toluidine-blue-stained slide of the tibial epiphysis in lathyric and control chicks of the two age groups were practically comparable. Also no apparent difference was noticed when the specimens were stained by the Hale acid mucopolysaccharide technique (Hale 1946).

On the other hand, the P.A.S. showed an appreciable decrease in the staining of ground substance in the tibial cartilage of the lathyric chicks, with individual variations. In the extreme cases the nearly colourless ground substance revealed a concentration of staining material in the capsules and a network of fibres, some single, some double and some bifurcating, which joined the individual lacunae across the ground substance (Fig. 4).

In demineralised sections stained with H.P.O. the osseous tissue appeared generally thinner, with gross deformations probably caused by pressure (Fig. 3). Two sites of metaphysial fractures were observed in the tibiae, with haemorrhage and no sign of repair. Elsewhere, abnormal periosteal proliferation accompanied by exaggerated bone formation was evident (Fig. 2).

The osteoblasts appeared to have decreased rapidly in size and number. They tended to coalesce into thin strips of three to five cells and finally disappeared.

The bone matrix appeared somewhat granular and not homogeneous; and the osteocytes seemed more numerous than usual, particularly in the newly formed zones. Sometimes these cells were enlarged and contained acidophilic granular material in their cytoplasm. The lacunae were enlarged. The Hale acid mucopolysaccharide stain revealed an exaggerated amount of blue staining material at their immediate border and along the canaliculi, which were thus very clearly visible.

The demineralised sections were entirely negative to the von Kossa reaction.

The mineralised sections submitted to the von Kossa test, and also the sections of material treated by Lillie's method of silver impregnation, produced roughly comparable pictures. In both controls and lathyric specimens the silver deposition was more extensive over the cartilage with Lillie's impregnation. The silver deposit, in general, appeared heavier in lathyric bony tissues. A closer inspection revealed that this condition was due to a large amount of precipitate in the marrow spaces, between the bone trabeculae, and sometimes, apparently, on the osteoblasts. However, it was evident that some of this extra-osseous precipitate was haphazard and artificial.

Mineralised sections stained with H.P.O. showed that some of this precipitate was probably endogenous and not a result of the silver nitrate treatment only, because basophilic masses were then revealed. These masses were irregularly distributed in the marrow spaces; they had irregular shapes, sizes and staining intensity, as if partly dissolved. In such

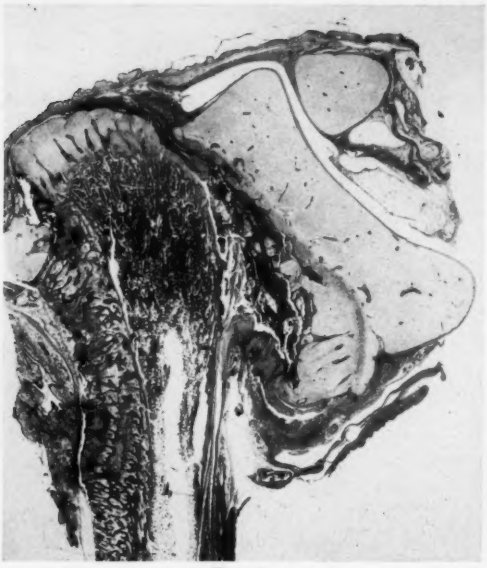

FIG. 2

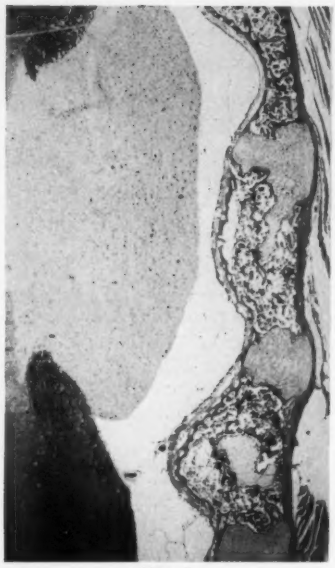

FIG. 3

Figure 2—The upper extremity of the tibia of a seventeen-day-old chick, on the osteolathyrogenic diet for seven days. Notice the slipped articular portion of the cartilage and the exaggerated bone growth on the left. (H.P.O. stain, ×6.) Figure 3—A portion of the lumbar section of the spinal cord and vertebrae in a chick fed on the osteolathyrogenic diet for seven days after birth. Notice the tumour, destruction of nervous tissue and vertebral deformity. (H.P.O., ×19.)

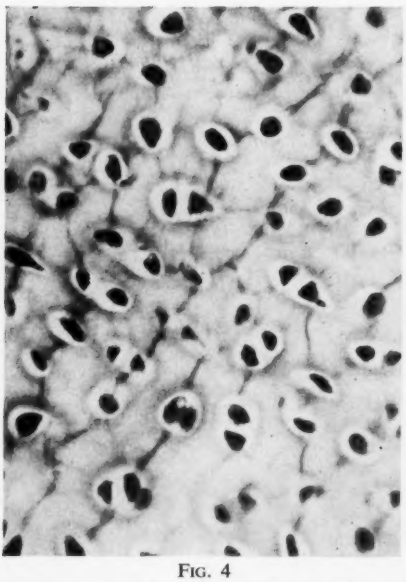

FIG. 4

FIG. 5

Figure 4—A portion of the growing cartilage from the upper extremity of the tibia of a chick fed the osteolathyrogenic diet for seven days after birth. Notice the capsular accumulation and the network of P.A.S. positive fibres. (Periodic acid-Schiff, ×550.) Figure 5—A portion of periosteal bone from the tibia of a chick of seven days fed on the osteolathyrogenic diet, unstained but photographed in polarised light to show the lack of mineralisation. Notice small birefringent osteoblasts at the borders of the trabeculae, larger birefringent osteocytes within the trabeculae and extra-trabecular crystalline masses of various sizes. (×400.)

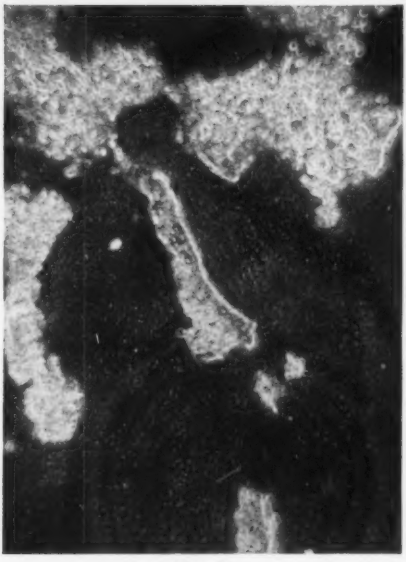

FIG. 6

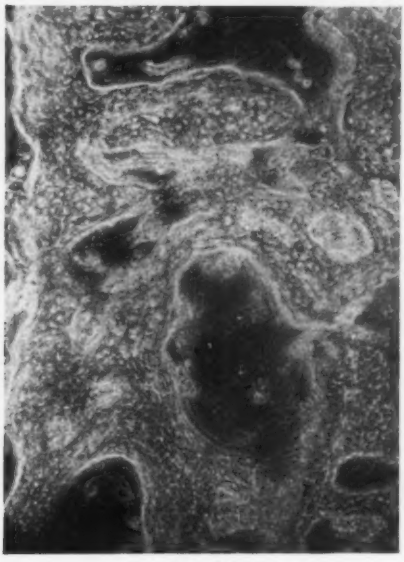

FIG. 7

Figure 6—A section of mineralised bone and cartilage from the tibia of a control chick of seven days, photographed unstained in dark M phase. Only the mineralised bone and cartilage are bright. The osteoblasts and marrow cells are dark. (×240.) Figure 7—A section of mineralised bone from the tibia of a chick fed on the lathyrogenic diet for seven days. Some osteoblasts are now bright and are tending to coalesce. Some osteocytes within the trabeculae are also bright. (×240.)

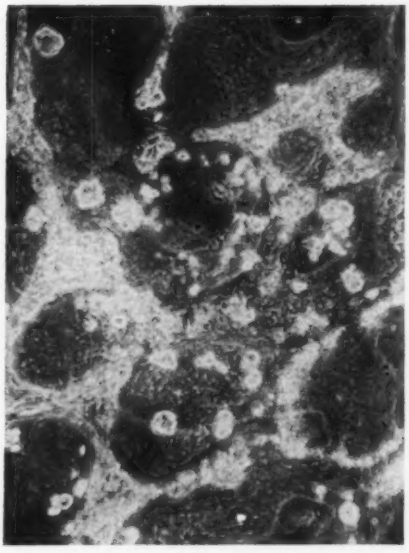

FIG. 8

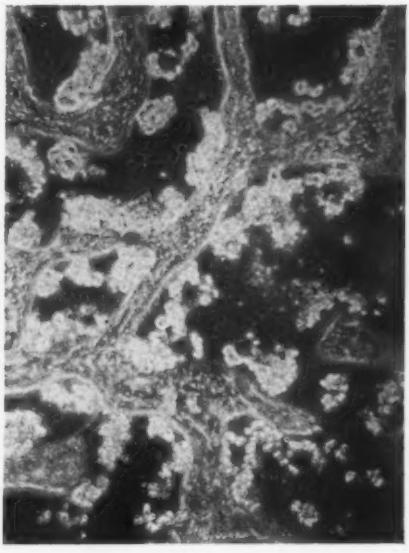

FIG. 9

Two aspects of mineralised bone from tibiae of chicks fed on the lathyrogenic diet for seven days after birth. In these apparently more severely affected birds the trabeculae are thin, the osteoblasts are rare and numerous crystalline objects inhabit the marrow spaces. (×240.)

preparations the more mature osteoblasts and some osteocytes were strongly basophilic. The strongly basophilic osteoblasts were thin and had a tendency to coalesce in small groups. The ferric iron-Prussian blue substitution technique for calcium (McGee-Russell 1958) produced a deep blue stain in all recent areas of mineralisation in cartilage and at the periphery of the bone trabeculae. The basophilic masses described above were also deeply stained. Osteocytes were coloured irregularly and with variable intensities. Many small osteoblasts at the immediate border of the trabeculae or at some distance from it showed a deep blue reaction over their cytoplasm. These deeply stained areas present in mineralised sections were easily distinguished from the pale blue background of the tissue and were not present in demineralised controls.

Unstained mineralised sections revealed, under polarised light, the presence of birefringent masses of various sizes, each consisting of individual smaller particles, apparently crystals which had thus conglomerated (Fig. 5). The bone trabeculae contained a majority of small birefringent particles with a scatter of larger brilliant masses. Some of these were definitely inside the lacunae and were probably in relation to the osteocytes (Fig. 5). Small groups of osteoblasts at the borders of the bone trabeculae were also birefringent.

The clearest picture of the abnormal mineral deposits in lathyric bones was obtained when the unstained mineralised sections were examined in phase contrast. Sections of the normal tibiae showed that the only bright objects visible in dark phase were the mineralised portion of the cartilage and the bone trabeculae (Fig. 6). The osteoblasts lining the bone trabeculae appeared dark with a narrow but clear halo around them and the same condition prevailed for the marrow cells.

The early lesion of lathyrism was characterised by the presence of bright osteoblasts which appeared singly or in small linear clusters at the borders of the bone trabeculae (Fig. 7), with large brilliant clusters, probably representing osteocytes within the trabeculae.

In the more affected parts of the bone the osteoblasts were difficult to identify, the trabeculae were thinner (Figs. 8 and 9) and in the marrow spaces very numerous brilliant masses were visible as single small units or as clusters of various sizes. The osteoclasts and elements of the marrow never appeared as bright objects.

DISCUSSION

The observations given above reveal that young chicks are affected early by the toxic lathyric seeds. There are few exceptions. Birds ten days old respond as rapidly and dramatically as one-day-old chicks. The symptoms and signs are mainly related to the skeleton. However, the general hyperaemia, subcutaneous haemorrhages, discoloration of feathers and the meningeal tumour (Fig. 3) point to a systemic syndrome involving all mesodermic derivatives. A recent study of wound healing (Krikos and Orbison 1958) revealed that although fibroblastic proliferation was more intense, granulation tissue was thinner and the number of collagen fibres was decreased.

It seems evident that the ground substance of cartilage is modified. The disorganisation of the columns of cells, accompanied by enlargement of the inter-columnar spaces (Ponseti and Shepard 1954, Menzies and Mills 1957, Selye and Bois 1957*a*, Bélanger 1958), point at first to an increase in ground substance. However, the articular hyperaemia followed by cleavage and slipping of the epiphyses (Fig. 2), and the accumulation of fluid in pockets of various sizes (Selye and Bois 1957*a*), indicate a decrease in the polysaccharides. These are known to consist of a neutral polysaccharide fraction (Leblond 1950) and an acidic fraction, chondroitin sulphate (Dziewiatkowski 1951*a* and *b*; Dziewiatkowski, Di Ferrante, Bronner and Okinaka 1957; Bélanger 1954). In the lathyric cartilage of the present experiment the periodic acid Schiff stain showed a decrease of neutral polysaccharides in the ground substance, but revealed at the same time a relative concentration in the capsules and also a beautiful network of fibres joining all cellular units (Fig. 4). These fibres are probably

a normal feature of cartilage which is masked, under ordinary circumstances, by the abundance of polysaccharides. Toluidine blue and the Hale colloidal iron reaction (Hale 1946) were not conclusive in showing any changes in the acid mucopolysaccharide content of the ground substance of cartilage. However, our autoradiographic studies on the cartilage of lathyric rats and chicks published elsewhere (Bélanger 1958) have been enlightening in this respect. The ability of individual cells to synthesise $S^{35}O_4$ into a product retained by formaldehyde-ethanol fixation is apparently maintained in the chicks at seven days and in the rat at ten and sixteen days. This fact confirms the observations of Ponseti, Wawzonek, Shepard, Evans and Stearns reported in 1956. On the other hand, *in vitro* Ca^{45} chelation by the cation absorbers in demineralised sections (Bélanger 1955, 1958) has indicated clearly a much lower residual content and consequently a more rapid change or disappearance of the chondroitin sulphate in the fast growing upper extremity of the tibia.

Consequently, even if the cartilage is larger and even if the ground substance seems more abundant, even if the rate of S^{35} uptake is definitely proved to be higher, the residual content of the ground substance is most likely lower in both neutral and acidic polysaccharides as a result of lathyrus intoxication.

The bone pathology reported in most of the literature (Geiger, Steenbock and Parsons 1933; Robinson and Bast 1934; Lewis and Esterer 1943; Ponseti and Shepard 1954; Strong 1956; Menzies and Mills 1957; Selye 1957; Selye and Bois 1957*a* and *b*) has been concerned with what appears now to be secondary and reactive lesions, which are certainly clearly evident macroscopically, in experiments of long duration and in histological studies after demineralisation. However, recent observations by Selye (1957) and Clemmons and Angevine (1957) have shown that there is a more detailed pathology of the pre-lathyric bone tissue and its cells, in which degenerative changes occur in the osteoblasts and in the osteocytes, the trabeculae become porotic and fragile; the bones are easily fractured and callus formation is not accompanied by mineralisation.

A comparable series of events occurred in our experiments with young chicks, with weakness of the bones, spontaneous fractures and eventually a callus-like periosteal reaction, tending to reinforce the structure, which is responsible for the gross external deformities.

The original damage, however, involved the bone cells, particularly the osteoblasts. It seems that the process of degeneration which eventually causes the disappearance of these cells involves at one time an influx of calcium salt into their cytoplasm. This "mineralisation" of the osteoblast is manifested by the positive von Kossa and Lillie silver nitrate reactions, and by the iron substitution-Prussian blue reaction. It is most likely responsible for the birefringence in polarised light (Fig. 5). Equally, this condition presumably causes the "induced brilliancy" in dark phase. In a recent survey of fluorosis (Bélanger, Visek, Lotz and Comar 1958*a* and *b*) bright masses in bones and teeth were shown to contain abnormal deposits of calcium.

The same observations apply to the osteocytes of recent formation, but apparently to a lesser extent (Figs. 6, 7 and 9). The more progressive lesions show also the formation of crystalline, coalescent masses in the spaces between the bone trabeculae (Figs. 8 and 9).

These hitherto unrecognised events in lathyrism seem to indicate that, in the absence of a regular osteoblast physiology, the mineral constituents do not reach the bone substance; they seem to be deposited in the cytoplasm of the osteoblasts, also in the recent osteocytes and eventually in the marrow spaces between the bone trabeculae.

These observations suggest that the toxic factors of the lathyrus seeds possibly act as enzyme poisons in the formative cells of bone. The resulting "calcification" of the cells allows speculation on the normal activity and role of these cells in the transit and deposition of minerals.

According to a recent review (Pritchard 1956) the osteoblasts have an essential role in "the production of collagen and alkaline phosphatase and possibly of organic phosphate substrates and mucopolysaccharides as well."

The present observations on osteolathyrism indicate that these cells and also the young osteocytes may well be directly involved in the mechanism of mineralisation.

SUMMARY

1. Severe osteolathyrism has been induced in chicks of different ages by a diet containing 50 per cent seeds of Lathyrus odoratus.
2. In these chicks, most of which became paraplegic after seven days, a meningeal tumour, articular and bony deformities, spontaneous fractures and osteoporosis have been observed.
3. In cartilage the lesion involves depletion of both neutral and acidic polysaccharides.
4. The primary effect on bone consists of changes in the osteoblasts and in the osteocytes involving cytoplasmic granulation and vacuolation, "mineralisation" and eventual disintegration of the cells.
5. These events are followed by osteoporosis, abnormal mineral deposits in the marrow spaces and reactive callus-like activation of the periosteum.
6. The role of the osteoblast and of the osteocyte in mineral transit and deposition is reconsidered.

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SKELETAL LESIONS PRODUCED BY SEMICARBAZIDE AND EXPERIMENTAL ANALYSIS OF THE ACTION OF LATHYROGENIC COMPOUNDS

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Laboratory animals fed on a diet containing either beta aminopropionitrile (BAPN) (NH_2. CH_2. CH_2. CN), the toxic factor in sweet peas (Lathyrus Odoratus), or amino acetonitrile (NH_2. CH_2. CN), develop various skeletal lesions such as scoliosis, displacement of epiphyses, osteochondritis and dislocation of joints. The term osteolathyrism has been applied to these lesions (Selye 1957). In a previous report on the skeletal lesions produced by BAPN, it was suggested that they might be due to an alteration in the ground substance of the epiphysial plate and interference with endochondral ossification (Ramamurti and Taylor 1958*a*). Similar lesions produced by mercaptoethylamine (NH_2. CH_2. CH_2. SH) have also been the subject of a previous study (Ramamurti and Taylor 1958*b*). According to Dasler (1958), semicarbazide (NH_2. NH. CO. NH_2) also had lathyrogenic properties, but he did not describe the pathology of the lesions.

This report is a histological study of some aspects of the lesions produced by semicarbazide. Repetition of findings already published in connection with other lathyrogenic compounds will be avoided. The description will be confined to the epiphysial plate and an attempt will be made to demonstrate the mechanism of the spinal deformity. The action of the lathyrogenic compounds will be analysed in the light of a number of experiments performed in this laboratory.

MATERIALS AND METHODS

Fifty Wistar rats, three weeks old, freshly weaned and weighing between thirty-five and forty grammes, were divided into two groups:

Group I—Twenty-five rats were fed on a standard diet (Ration No. 10 supplied by Buckerfield Feed Company).

Group II—Twenty-five rats were fed on a standard diet with which semicarbazide hydrochloride was mixed so that it made a concentration of 0·3 per cent. in the diet.

The animals in each group were killed at the end of six weeks and radiographs were taken. The knee joint, shoulder joint and thoraco-lumbar spine were selected for histological study. The tissues were fixed in 10 per cent formol alcohol and decalcified with normal hydrochloric acid. Paraffin blocks were prepared and serial sections from each block were stained with haematoxylin and eosin, 0·1 per cent aqueous toluidine blue and periodic acid Schiff (McManus method).

RESULTS

All the experimental animals (Group II) showed advanced skeletal lesions (Fig. 1). These consisted of severe kyphoscoliosis, bowing of the long bones, displacement of epiphyses, dislocations of joints and periosteal new bone formation at the attachment of tendons and ligaments. The lesions were identical with those produced by BAPN, with the exception of the spinal deformity. The severe kyphoscoliosis was peculiar to the animals in the present experiment and consisted of a sharp curve involving a short segment of the spine, with the summit of the curve at the twelfth thoracic or first lumbar vertebra (Fig. 2). About two

vertebrae above and below were included in the arc of the curve. This pattern was constant in all the animals of Group II. The angulation of the spine was so sharp that in some of the animals there was compression of the spinal cord and paraplegia. On the other hand animals on BAPN had a diffuse scoliosis without such a marked degree of kyphosis.

FIG. 1

Radiograph of a rat fed on semicarbazide for six weeks. The points to be observed are the severe scoliosis, the irregularity and displacement of both upper tibial and upper humeral epiphyses, and the periosteal new bone along the shaft of the femur, the infraglenoid part of the scapula and at the insertion of the deltoid on the shaft of the humerus.

FIG. 2

Lateral radiograph of the same rat as in Figure 1. The sharp kyphosis involving a short segment of the thoraco-lumbar spine with the apex at the twelfth thoracic vertebra is shown very clearly.

Microscopically, the most advanced changes were noted in the lower end of the femur and the upper ends of the tibia and humerus. These were characterised by a marked widening and disorganisation of the epiphysial cartilage with a disruption of the various zones (Figs. 3 and 4). The *zone of maturing cartilage* was abnormally wide and accounted for the general enlargement of the plate (Fig. 5). There were tears in the matrix of the epiphysial cartilage, which permitted a shearing of the epiphysis through the cartilaginous plate, resulting in

displacement and angulation. There were linear areas of periodic acid Schiff positive staining material in the ground substance (Figs. 4 and 5). Various areas of decreased metachromasia were also seen but these were not constant.

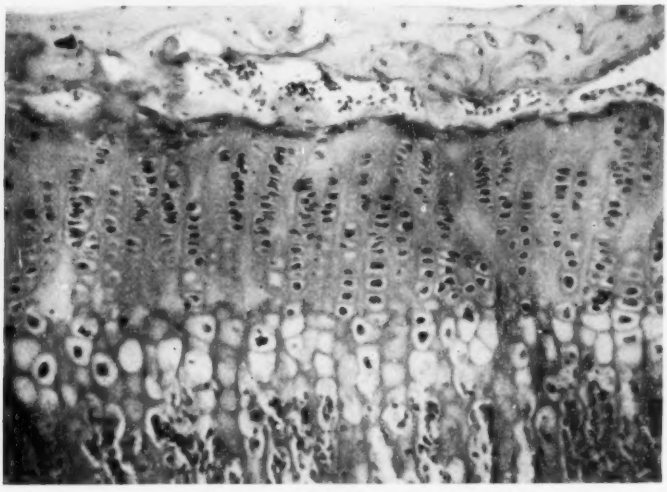


FIG. 3

The upper tibial epiphysis of a normal rat shows that the epiphysial plate is narrow and there is a regular and orderly arrangement of the various zones. The matrix is periodic acid Schiff negative. (Periodic acid Schiff, ×150.)

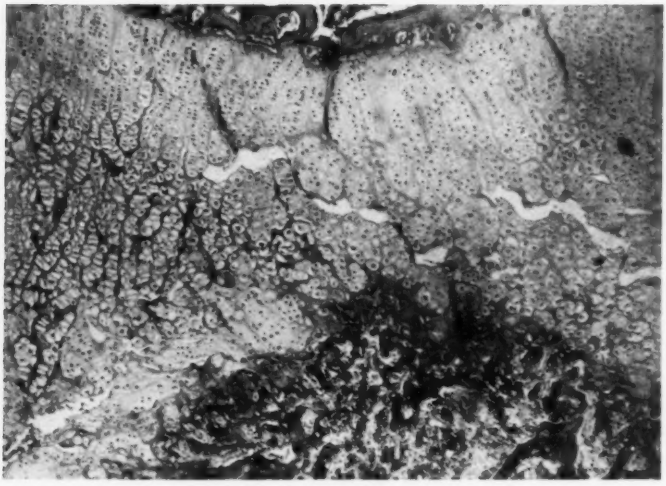


FIG. 4

The upper tibial epiphysial plate of a rat fed on semicarbazide for six weeks. There is a widening of the epiphysial cartilage with disorganisation of the various zones and tears in the matrix. Observe the linear areas of positive periodic acid Schiff material in the ground substance and compare with normal epiphysial plate shown in Figure 3. (Periodic acid Schiff, ×45.)

The epiphysial changes described above were most severe in the long bones of the extremities. Though not so dramatic, they were also present in the epiphysial plates of the twelfth thoracic or first lumbar vertebra (Fig. 6). The enlargement of the plate and the

disorganisation were not so marked, but there were tears, severe angulation and displacement at and through the epiphysial plate resulting in a well marked kyphosis. These changes were found only in the twelfth thoracic or first lumbar vertebra or occasionally in both. Perhaps,

FIG. 5
High power of the same section as in Figure 4. The major portion of the widened epiphysial plate consists of the zone of maturing cartilage cells. Again observe the periodic acid Schiff positive material in the ground substance. (Periodic acid Schiff, ×110.)

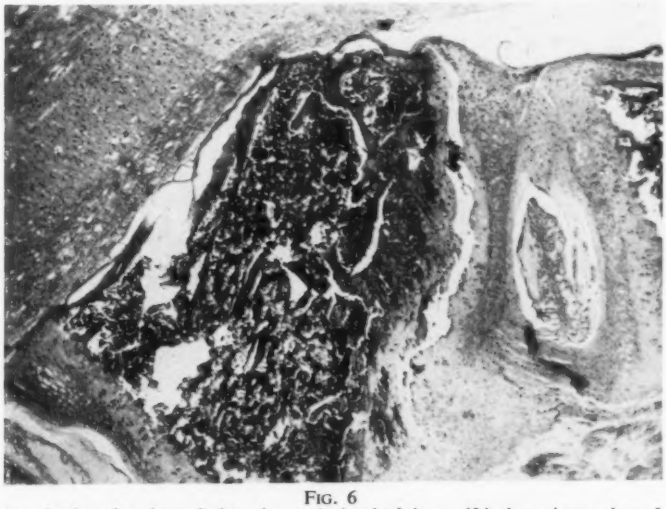


FIG. 6
A sagittal section through the spine at the level of the twelfth thoracic vertebra of a rat on semicarbazide for six weeks. There is disorganisation and a tear in the epiphysial plate through which the angulation occurs. The spinal cord at the *top left* of the picture is compressed. (Haematoxylin and eosin, ×30.)

because of increased metabolic or mechanical stress, these particular vertebrae are more vulnerable. The epiphysial plates of the other vertebrae showed insignificant changes, but frequently degeneration of the annulus fibrosus of the intervertebral discs was noted in various segments of the spine.

DISCUSSION

There has been some uncertainty about the mechanism of the spinal deformity in osteolathyrism. On the basis of a study of the spine in the animals on semicarbazide, it is clear that the kyphoscoliosis was due to a derangement and displacement at and through the epiphysial plate of the vertebra (Fig. 7). This clearly demonstrates that experimental changes in the epiphysial plates of vertebrae can be a cause for abnormal curvatures of the spine.

The mode of action of the lathyrogenic compounds is not known. In the light of a considerable number of experiments done in this laboratory and the great strides that have been made by other workers (Zambotti 1957) in the study of the biochemistry of the epiphysial plate, an attempt will be made to correlate the possible mode of action of these compounds with the metabolism of the epiphysial plate.

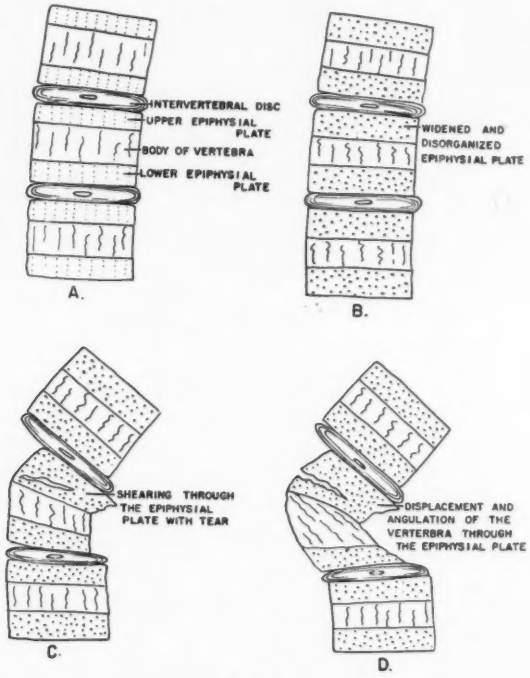


FIG. 7

The mechanism of the spinal deformity that occurs in rats fed on semicarbazide is shown here diagrammatically.

The normal epiphysial plate is narrow and shows an orderly and regular arrangement of the following zones: the zone of resting cartilage, the zone of proliferating cartilage, the zone of maturing cartilage, the zone of calcifying cartilage (Fig. 8). As there is a coordinated sequence of cellular processes, proceeding in equilibrium, the dimensions of the various zones are kept constant (Sissons 1956). There are three dynamic mechanisms in the metabolism of the epiphysial plate in its orderly regimented process of endochondral ossification:

1. The energy mechanism: (*a*) glycolytic cycle, (*b*) tricarboxylic cycle (Krebs cycle).
2. Synthesis of chondroitin sulphate and ground substance.
3. The mineralisation process.

Both the anaerobic glycolytic cycle and the oxidative tricarboxylic cycle are known to occur in the metabolism of the epiphysial plate. From the available evidence as reviewed by

Zambotti (1957), the tricarboxylic cycle is more prominent at the *zone of maturing cartilage*, where there is an abundant supply of oxygen. On the other hand the glycolytic cycle, taking place in the absence of oxygen, is more prominent in the *zone of proliferating cartilage*, which is the relatively avascular part of the plate (Fig. 8).

Beta aminopropionitrile, semicarbazide and mercaptoethylamine produce more or less similar gross lesions in laboratory animals. In all three conditions there is a widening and disorganisation of the epiphysial plate. But the histology of the epiphysial cartilage in the

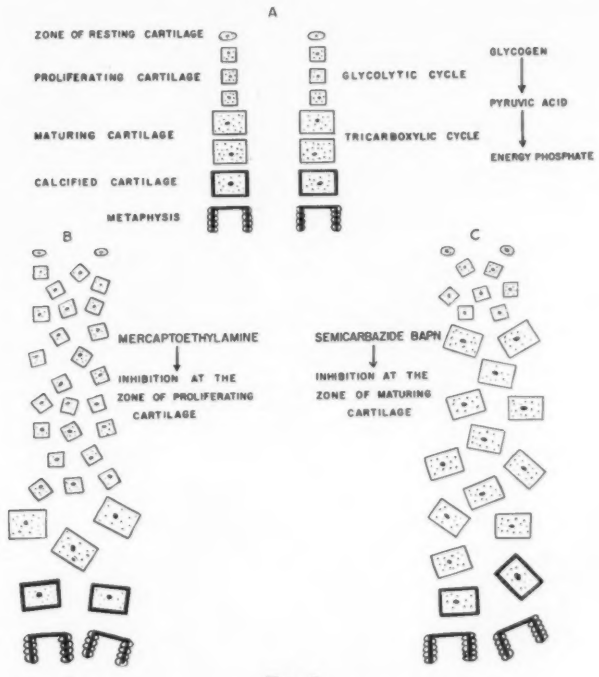


FIG. 8

This diagram shows the epiphysial plate of (A) a normal rat, (B) a rat on mercaptoethylamine, and (C) a rat on either BAPN or semicarbazide. In the normal rat (A) the plate is narrow with an orderly arrangement of the different zones. The zones of the glycolytic cycle and tricarboxylic cycle are also indicated and correspond respectively to the proliferating cartilage and maturing cartilage. In (B) there is disorganisation and maximal widening of the zone of proliferating cartilage. In (C) the disorganisation and maximal enlargement is due to the zone of maturing cartilage.

lesions caused by mercaptoethylamine is significantly different from that produced by BAPN and semicarbazide. In the lesions due to BAPN and semicarbazide, abnormal widening of the *zone of maturing cartilage* is mainly responsible for the enlargement of the plate (Fig. 10). There is a block to further differentiation at this zone and, as further development is inhibited, there is a disturbance of the equilibrium and an undue widening of this area. In terms of metabolic process, this is the zone of the tricarboxylic cycle and it is possible that these two compounds may affect this cycle (Fig. 8).

On the other hand the lesions due to mercaptoethylamine (Ramamurti and Taylor 1958*a*) are characterised by a preferential enlargement of the *zone of proliferating cartilage* from

interference with further differentiation of this zone (Figs. 8 and 9). The glycolytic cycle is the main metabolic event at this zone. Mercaptoethylamine may affect this cycle. However, these interpretations are mere speculations and must await direct biochemical proof.

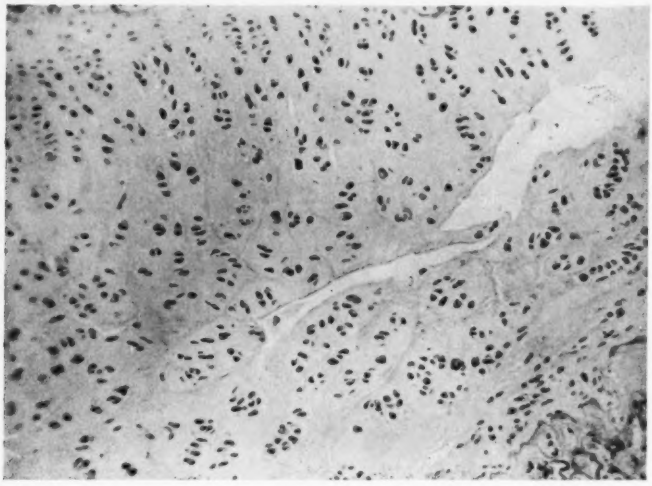


FIG. 9

The upper tibial epiphysial plate of rat fed on mercaptoethylamine for eight weeks shows widening and disorganisation of the epiphysial cartilage mainly due to increased width of the zone of proliferating cartilage which occupies almost the whole width of the plate. (Haematoxylin and eosin, ×110.)

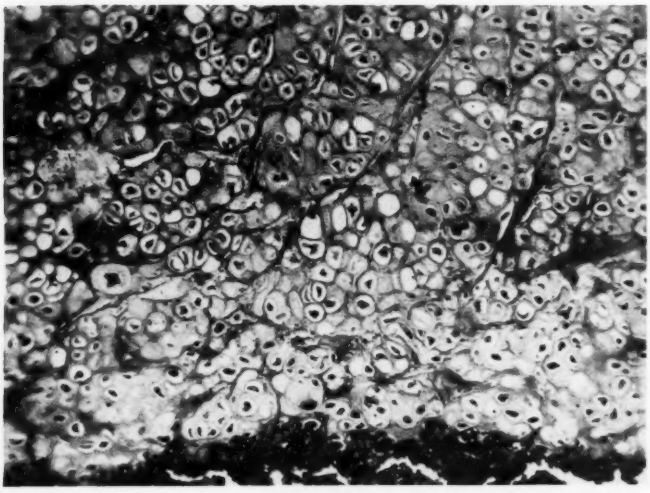


FIG. 10

Compare this epiphysial plate of rat fed on BAPN for four weeks, with that shown in Figure 9.. There is gross disorganisation and marked widening of the zone of maturing cartilage. (Haematoxylin and phloxine, ×110.)

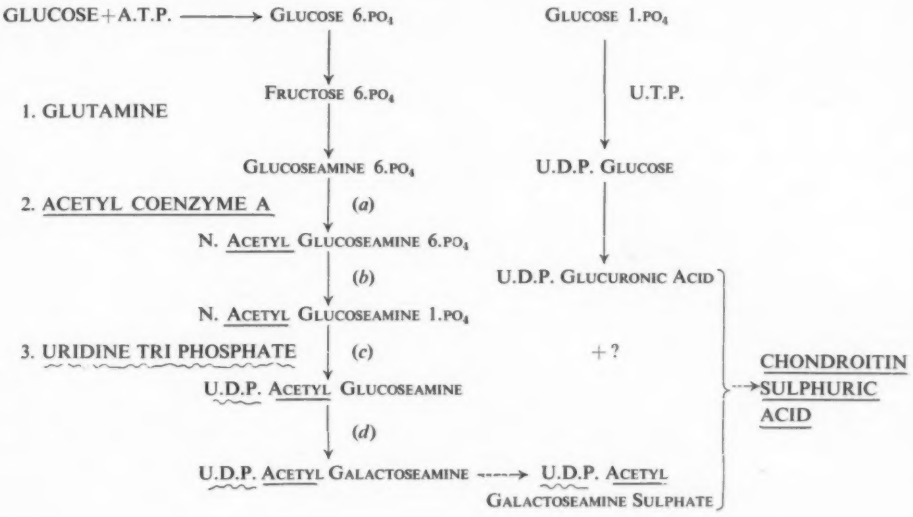
Histochemical study of the lesions produced by all the lathyrogenic compounds shows characteristic alterations in the periodic acid Schiff reaction and at times altered metachromatic staining of the epiphysial plate, which suggests that there is decreased polymerisation of the

ground substance (Ramamurti and Taylor 1958*a*). This has been confirmed by other workers (Pyörälä, Punsar, Seppälä and Karlsson 1957).

Ground substance of cartilage consists mainly of glycoproteins, made up of a carbohydrate moiety, chondroitin sulphuric acid and a protein fraction which has not been clearly elucidated. Acetyl galactoseamine sulphate and glucuronic acid occur in a highly polymerised form in chondroitin sulphuric acid. Calkins, Soodak and Bauer (1955) have put forward a tentative scheme based on *in vitro* enzymatic studies, for the synthesis of chondroitin sulphuric acid which is presented in Table I. Though there is considerable evidence to support it, it has a limitation that *in vivo* reactions may be different. The prominent chemical participants are: 1) glutamine which combines with the carbohydrate to form glucoseamine-6-phosphate, 2) acetyl co-enzyme A which brings about acetylation, and 3) uridine-tri-phosphate which is active in many carbohydrate reactions.

TABLE I

Tentative scheme for the interconversion of body sugar compounds based on *in vitro* enzymatic studies. Evidence for the steps designated by the letters (*a*), (*b*), (*c*) and (*d*) is available. (Modified from Calkins, Soodak and Bauer 1955.)



With this scheme as a basis, certain studies were done in this laboratory. Animals receiving BAPN were divided into three groups; one group received 3 per cent glutamine in diet, the second and third groups received parenterally one milligram of co-enzyme A and uridine-tri-phosphate respectively. These were administered daily but did not prevent the development of skeletal lesions, which suggests that the lathyrogenic agents do not exert their influence at these particular sites of the metabolic pathways.

Be that as it may, the indications are that these different compounds produce the characteristic deformities by affecting directly or indirectly the metabolism of the epiphysial cartilage. The lathyrogenic agents are all short-chain organic compounds and have in common an amino group at one end of the chain; the other groups in the compounds vary one from the other. In order to ascertain whether a specific reactive group might be responsible for the biochemical reactions involved in the production of osteolathyrism, a series of chemicals were

selected that bore a close resemblance to the proven lathyrogenic compounds. These chemicals, tabulated in Table II, were fed to experimental animals as a percentage of the diet as indicated. In no instance were skeletal lesions produced. This suggests that the interference with the metabolism of epiphysial cartilage is not mediated through a specific reactive group or chemical configuration.

SUMMARY

1. Young Wistar rats fed on a diet containing 0·3 per cent semicarbazide hydrochloride developed the characteristic lesions of osteolathyrism. This consisted of kyphoscoliosis, displacement of epiphyses and dislocations of joints. A pathological study of the skeletal lesions showed widening, disorganisation and tears of the epiphysial plate with the zone of maturing cartilage showing the greatest increase in width. The severe kyphoscoliosis was due to a derangement and displacement at and through the epiphysial plates of the twelfth thoracic or first lumbar vertebra.

2. Some of the compounds that are known to produce osteolathyrism in laboratory animals are beta aminopropionitrile, amino acetonitrile, mercaptoethylamine and semicarbazide. The mode of action of the lathyrogenic compounds was analysed in the light of a number of experiments done in this laboratory.

3. It is possible that they interfere with the metabolism of the epiphysial plate. There appears to be a decreased polymerisation of the ground substance of the epiphysial cartilage, but the exact metabolic reaction involved is not known. Other chemicals of similar structure,

TABLE II

List of compounds fed to young Wistar rats at the concentrations indicated for ten weeks or more. Compounds marked × were reported by Wawzonek, Ponseti, Shepard and Wiedenmann (1955) and were not tried in this laboratory. Only the compounds underlined produced skeletal lesions, while the other chemicals resembling these compounds were ineffective.

	COMPOUND	FORMULA	SKELETAL LESIONS
I.	β AMINO PROPIONITRILE 0·5%	$H_2N\ CH_2\ CH_2\ CN$	+ + +
	AMINO ACETONITRILE 0·2%×	$H_2N\ CH_2\ CN$	+ + +
	AMINO BUTYRONITRILE 0·2%×	$H_2N\ CH_2\ CH_2\ CH_2\ CN$	−
	α AMINO PROPIONITRILE 0·2%×	$CH_3\ CHNH_2\ CN$	−
	SUCCINONITRILE 0·8%	$CN\ CH_2\ CH_2\ CN$	−
	CYANAMIDE 0·2%	$H_2N\ CN$	−
	DICYANDIAMIDE 2·0%	$H_2N\ CN\ HNH\ CN$	−
II.	SEMICARBAZIDE 0·3%	$H_2N\ NH\ CO\ NH_2$	+ + +
	GLYCINEAMIDE 2·0%	$H_2N\ CH_2\ CO\ NH_2$	−
	GUANYLUREA 2·0%	$H_2N\ CN\ HNH\ CO\ NH_2$	−
	GUANIDINE 0·6%	$H_2N\ NHC\ NH_2$	−
	AMINOGUANIDINE 0·5%	$H_2N\ CNH\ NH\ NH_2$	−
	HYDRAZINE 0·2%	$H_2N\ NH_2$	−
	HYDROXYLAMINE 2·0%	$H_2N\ OH$	−
	PHENYLHYDRAZINE 0·3%	$H_2N\ NH\ C_6H_5$	−
	METHYLAMINE 2·0%	$H_2N\ CH_3$	−
	ETHYLAMINE 1·0%	$H_2N\ CH_2\ CH_3$	−
III.	MERCAPTOETHYLAMINE 0·5%	$H_2N\ CH_2\ CH_2\ SH$	+ +
	ETHANOLAMINE 2·0%	$H_2N\ CH_2\ CH_2\ OH$	−

with the same reactive groups, did not show lathyrogenic properties. It is concluded that it is not a particular chemical structure, configuration or specific reactive group that is responsible for the production of osteolathyrism. The chemistry of the lesions still remains to be solved.

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EARLY SKELETAL AND VASCULAR CHANGES IN RATS FED ON SWEET PEA (LATHYRUS ODORATUS) SEEDS

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The disease caused by the copious ingestion of leguminous food was first recognised by Ramazzini, who described an outbreak of lathyrism in Modena in 1690, but it is probable that it had been known by Hippocrates (Stockman 1929). In 1868 Irving referred to the prevalence of the illness in India and described its main features, particularly muscle spasm; he found that 7 per cent of the population under review were affected. Acton (1922) studied the disease in the population of the town of Ravat (India) and found that about 6 per cent of the children showed signs of lathyrism. Vivanco and Jiménez Díaz (1951) described similar findings in Spain. Stockman (1929) reported his results of feeding guinea pigs on sweet pea meal; all died within one to five weeks. He believed that the cause was not so much poisoning as a deficiency state due partly to scurvy.

The deleterious effects of leguminous diet have been ascribed to an alkaloid (devicine) by Anderson, Howard and Simonsen (1925), isolated by them from Lathyrus odoratus, the sweet pea.

Lee (1950) found that the acid of the stomach destroyed this alkaloid, thus excluding the probability that it caused lathyrism due to an ingested leguminous diet. He also exonerated enzymes, as the toxic factor persisted after boiling. Dupuy and Lee (1954) reported the isolation of a crystalline substance, later identified as B (Y–L glutamyl) aminopropionitrile by Schilling and Strong (1954).

Ponseti and Baird (1952) and Ponseti and Shepard (1954) reported the first experimental observations on the disease process with special reference to its effect on the skeleton and the rest of the mesodermal system. They described a widespread lesion of the epiphysial plates and a loosening and detachment of ligamentous and tendinous insertions causing many varied lesions and deformities, some of the latter probably being sequelae and not part of the disease entity. They believed that the active principle contained in the lathyrus pea, producing the skeletal changes, was B-aminopropionitrile.

The present work has been undertaken in order to study the earliest changes of the disease in the skeleton, and to detect the role played by blood vessels in the affected regions. It was also hoped to determine whether the changes were reversible or not.

METHOD

Twelve thirty-five-days-old albino rats taken from the same litter were used in the experiment and were divided into three groups of four, A, B and C. Group A was used as a control, group B was fed on a pea-meal diet‡ and the last group, C, was fed on the pea-meal diet for ten days and then returned to a normal diet (standard laboratory N.41 diet). Radiographs of the anaesthetised animals were taken at intervals. One rat from each group was killed by an injection of Nembutal at intervals of fourteen, eighteen, twenty-two and twenty-six days

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† British Council Scholar.

‡ Diet N. 3 as used by Ponseti and Shepard (1954):

Pea meal	50%	Wheat germ oil	2 ml. per 100 gr.
Corn flour	28%	Dried yeast	10%
Sugar	6%	Halibut liver oil	2 ml. per 100 gr.
Salt mixture	4%		

after the start of the experiment, and was injected immediately with a mixture of equal parts of 10 per cent barium sulphate and Berlin blue and prepared for examination by the routine method described in previous papers from this Centre (Trueta, Barclay, Daniel, Franklin and Pritchard 1947; Trueta and Harrison 1953). The Gomori (1946) azo dye method was used to estimate the alkaline phosphatase content of the bone.

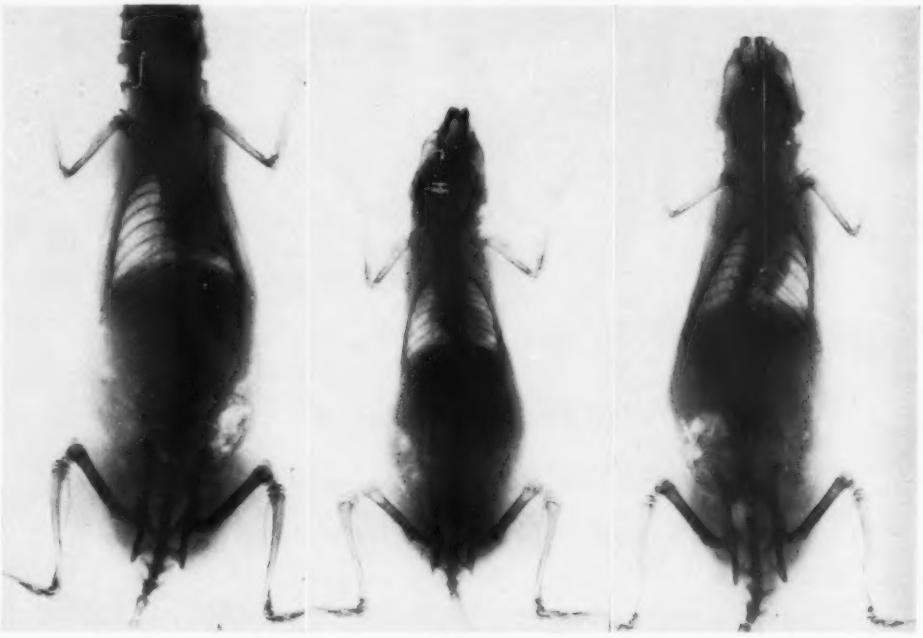

FIG. 1 FIG. 2 FIG. 3

The relative sizes of the rats in the three groups, all from the same litter. Figure 1—Control. Figure 2—Experimental rat after twenty-six days of pea-meal diet. Note the generalised osteoporosis, and the exostoses in the region of the deltoid. Figure 3—An experimental rat fed on pea-meal for ten days and then returned to a normal diet for sixteen days.

RESULTS

The pea-meal diet retards growth and appears to be a systemic poison, as all animals on the experimental diet were much smaller and less active than the controls (Figs. 1 to 3).

After twenty-two and twenty-six days of diet the mean differences in weight were:

	22 days	26 days
Group A	130 grammes	180 grammes
Group B	100 grammes	75 grammes
Group C	110 grammes	130 grammes

Note that the rats in group B were actually losing weight.

Radiological appearances—The earliest and most obvious radiographic changes after ten days' diet in groups B and C were the lack of skeletal growth and a narrowing of the growth plate. Early signs of osteoporosis were present. These changes became more evident after twenty-two and twenty-six days in group B; there was well marked patchy osteoporosis, most evident in the femora, vertebral bodies, sacrum and scapulae, and the texture of the skeleton as a whole became indefinite, especially in the region of the metaphyses (Fig. 2). The cortical bone was much thinner. The difference in size of the individual bones was still marked, and areas of

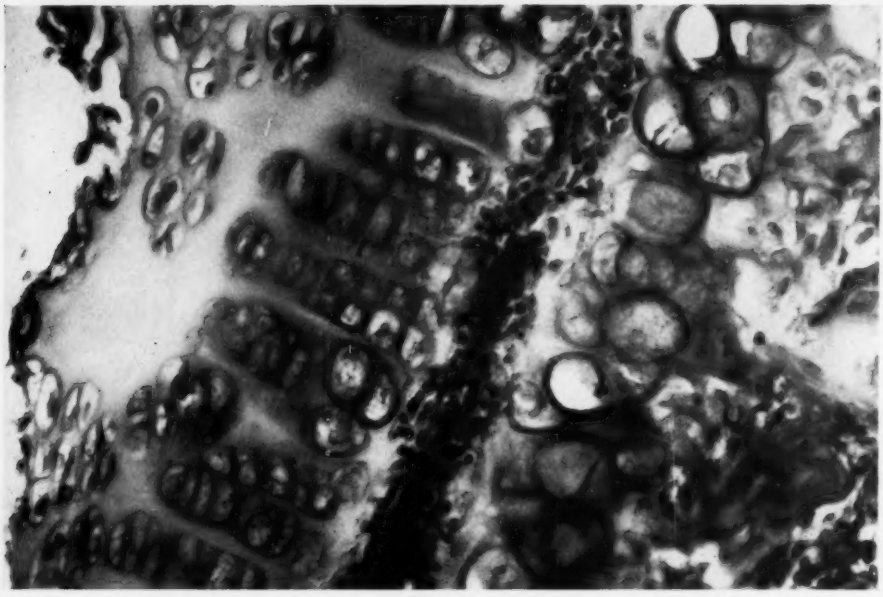

FIG. 4

Epiphysial plate showing the split in the growth plate between the zone of expanding cells and the "calcified" layer. The germinal layer is much thinner than normal. (×500.)

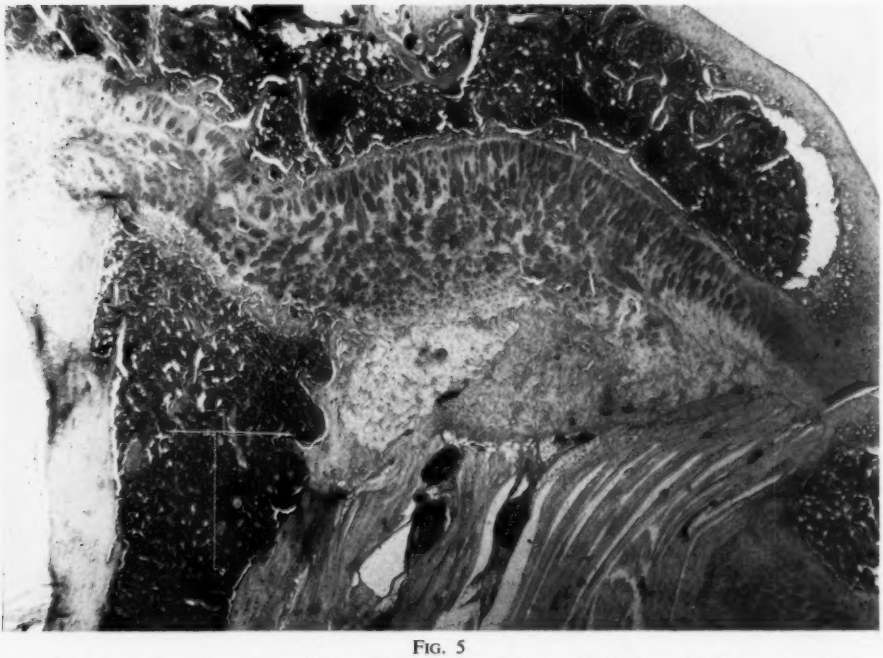

FIG. 5

The widening of the epiphysial plate of the tibia, and part of that of the fibula, which is caused mainly by non-ossification at the metaphysial end. (×40.)

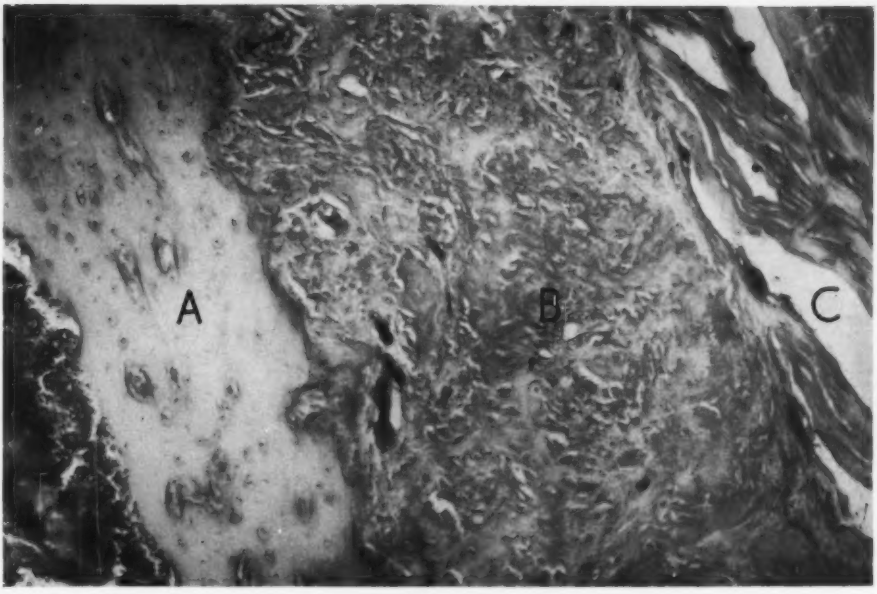

FIG. 6
Cortex and periosteum showing (A) cortex, (B) new bone formation three times the width of the original cortex, and (C) raised periosteum. (×100.)

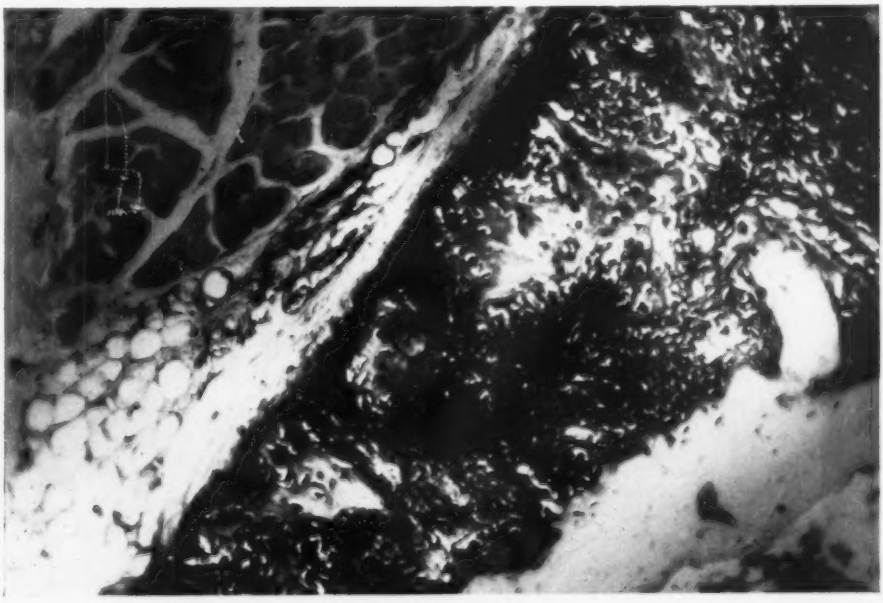

FIG. 7
Increased alkaline phosphatase activity in the region (B) shown in Figure 6. (×100.)

raised periosteum were present. At the insertion of the deltoid, biceps and quadriceps muscles and the calcaneal tendon large exostoses were raised from bones.

In the later radiographs the growth plates had widened and were irregular.

In the rats of group C, to which a normal diet was given after ten days, growth was seen rapidly to resume a normal rate and the above radiological findings did not develop (Fig. 3).

Histology—The earliest changes appeared after two weeks and consisted of a transverse split in the growth plate at the junction of the segment of hypertrophied chondrocytes and the segment of large, degenerating cartilage cells (Fig. 4). This area contained blood vessels and extravasated blood. There was a slight generalised osteoporosis.

After eighteen days bone rarefaction was evident in group B; the lamellae were thin and scanty both in the metaphysis and in the epiphysis. The periosteum was well attached to the cortex and there were no histological changes visible in the marrow cavity. The growth plate was slightly widened (Fig. 5) and showed metachromasia. The columns of chondrocytes were becoming disorganised near their metaphysial end, and the transverse splits noted above were now more evident. The increased width of the plate was due to hypertrophy of individual cells and lengthening of the cell columns by delayed ossification on the metaphysial side of the plate. It was not the result of hyperplasia in the germinal layers.

The changes were very pronounced after twenty-two days of pea-meal diet, and even more so after twenty-six days. Bone rarefaction, with sparse and attenuated lamellae, was present and the cortex was reduced to half the size of that of the control animals. In regions where the periosteum had become detached from the cortex new bone was laid down, occasionally to three times the normal width (Fig. 6). A marked increase in alkaline phosphatase activity was noted (Fig. 7).

In the metaphysis the trabeculae were so thin and far apart that there was often loss of continuity of the cortex. The periosteal detachment was advanced in some bones, and new bone was being laid down rapidly. The epiphysial cartilage became more than double its normal width, and the transverse defect previously mentioned was more in evidence, sometimes spreading right across the plate. These spaces were filled with new blood vessels and extravasated blood. Metachromasia was pronounced. The cells were large in all layers and the degenerate portion was much wider than normal. The normal columnar arrangement was absent, the cells having a haphazard arrangement with little or no intercellular matrix, or with a change in direction as if they were bent by a shearing force. In the lower end of the femur the growth plate widened to many times its normal size, and no ossification was taking place (Figs. 8 and 9). In other bones the upper end of the metaphysis was most irregular and there was complete absence of the orderly laying down of new bone on a calcified cartilaginous matrix (Figs. 10 and 11). In places the new bone marrow extended right up to the growth plate; islands of cartilage cells were scattered in the marrow. The mounting of these sections presented technical difficulties because of separation of the epiphysis from the shaft, and friability due to osteoporosis.

The blood vessels—The smaller blood vessels and capillaries were seriously affected.

The injection mass filled the vessels in the control rats without damage to their walls; in the rats on the pea-meal diet numerous " bursts " were present at the growing ends of the bones where the capillaries were most numerous (Figs. 12 to 14). In group C, " bursts " were also present but they were not so numerous.

Blood vessels were present in the growth plate at the site of the fissures—that is, at the junction of the zone of hypertrophic cells with the zone of calcification.

In the metaphyses of the rats in group B the capillary loops were thin and very attenuated when compared with those of the control group. They showed no orderly orientation in relation to the columns of cartilage cells and did not all reach the same level; thus the line formed by the vascular loops was always very irregular and sometimes was completely absent from whole sections. The altered line of vascular loops corresponded with the irregularity in the

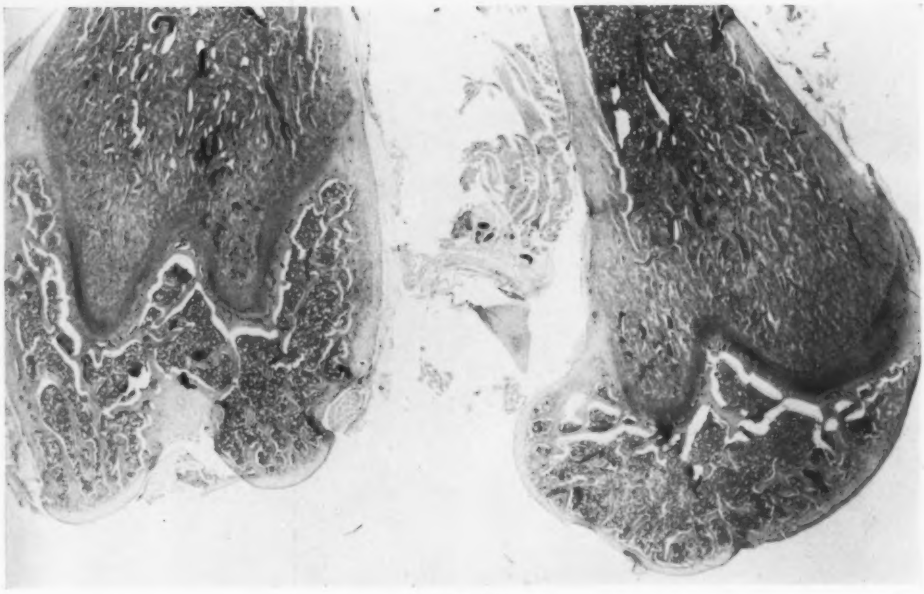

FIG. 8
The lower end of the femur in a control rat, a litter mate of that shown in Figure 9. (×12.)

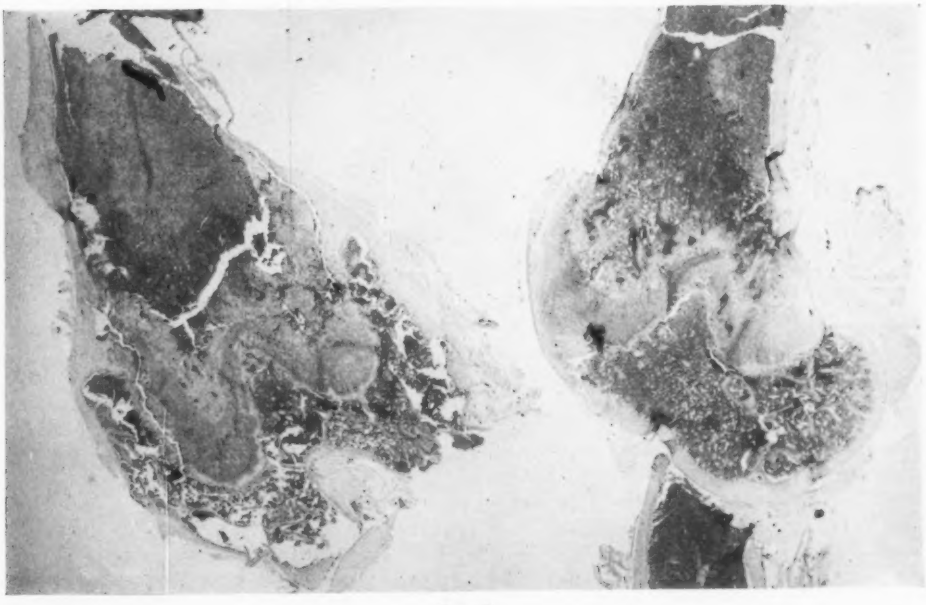

FIG. 9
The lower end of the femur of a rat after twenty-six days on pea-meal. The growth plate is wide and there is generalised decalcification. (×12.)

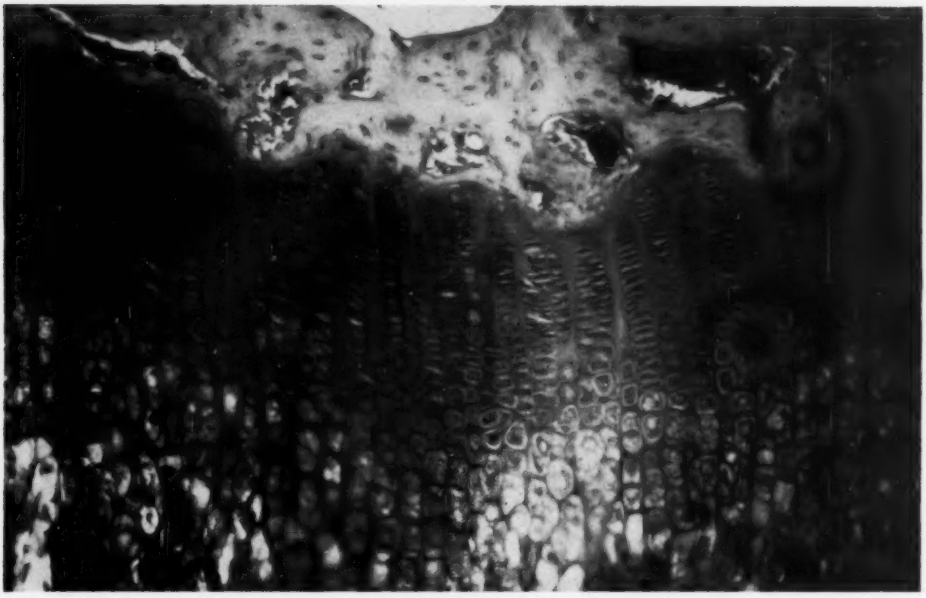

FIG. 10

The growth plate of a control rat showing the orderly columnar arrangement and bony trabeculae in the metaphysis. (×300.)

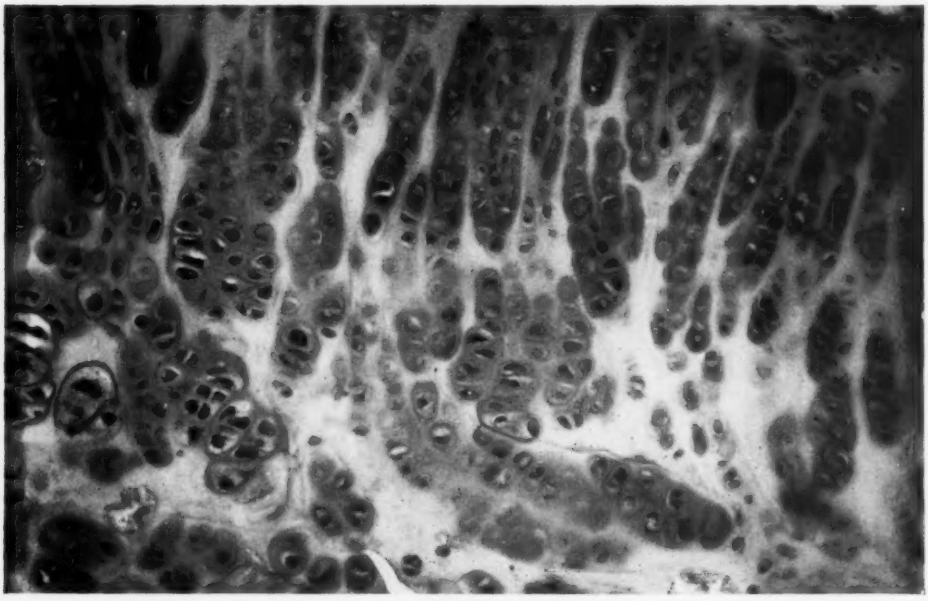

FIG. 11

The growth plate showing the effect of pea-meal. Note the loss of the columnar arrangement and the complete disorientation near the metaphysis. (×325.)

plate, which had become wider from an accumulation of the "degenerating" cells, sometimes appearing as broad finger-like processes directed towards the centre of the metaphysis, sometimes involving one-half of the metaphysis.

Bursts were numerous in the epiphyses also, and extravasated blood was present in the deeper layers of the articular cartilage. Similarly, bleeding was present under the periosteum.

Alkaline phosphatase—Alkaline phosphatase was present in excessive amounts in the nuclei of the degenerating cells and in the metaphysial region. It was abundant in the subperiosteal region when new bony trabeculae had been freshly laid down (Fig. 15).

DISCUSSION

In the course of this work it was found that the administration of pea-meal diet caused interference with growth, lesions of the smaller blood vessels, raising of the periosteum, formation of exostoses, and osteoporosis. Alkaline phosphatase activity was increased.

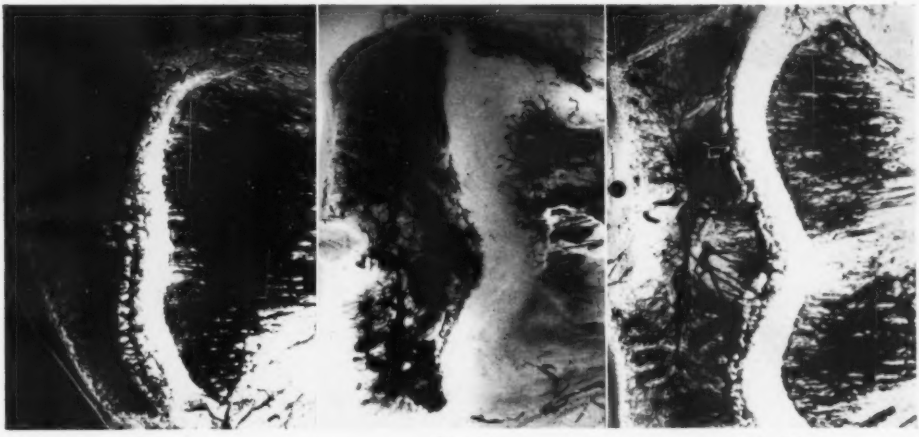

FIG. 12 FIG. 13 FIG. 14

The vascular pattern at the growth plate of a control and experimental rats. Figure 12—A control rat showing the regular vascular arrangement both in the epiphysis and metaphysis. Figure 13—The pattern in a rat fed on pea-meal shows numerous bursts in the epiphysis, with irregularity along the upper part of the growth plate and complete disorganisation in the metaphysis. Figure 14—The pattern is returning to normal in a rat returned to a normal diet after ten days on pea-meal.

The early manifestations of the disease have been studied in order to avoid confusion with their sequelae.

Growth—Interference with growth manifested itself in a failure of the rats to gain weight and increase in size when compared with the controls, and also in narrowing of the growth plates as seen in the radiographs taken at ten days. This may be due to a lack of stimulus of the growth hormone of the pituitary on the proliferative layer of the cartilage columns, or to a generalised metabolic disorder, or to both (Ray, Evans and Becks 1941). It may also have some connection with the early vascular damage we have detected.

Failure to gain weight persisted to the end; some animals were losing weight by the fourth week. The widening of the growth plate in the later stages was due to increase in size of the cells in the hypertrophic layer and to an accumulation of the cells of the degenerating zone, and not to hyperplasia in the proliferating zone, where the number of cells was diminished.

The plate becomes broken at a level that appears to be brittle in other conditions as well. Thus Harris (1950) found that it is at the zone between the hypertrophic and the degenerating layers of the columns that stress causes greatest damage. It may be that the split that appears

in this zone is due to a tearing or distracting force exerted by the expanding cells at the level where their increase in size appears to be most rapid. The new blood vessels enter this zone through splits between the cells of the degenerating layer.

The disorganisation of the columnar arrangement in the plate seems to be caused by an absence or decrease of the intercellular substance, and by the absence of the regular honeycomb arrangement of calcified cartilage matrix laid down by the normal growth plate. Serious interference thus occurs in ossification.

The abnormal blood vessels alone could also be responsible for the widened growth plate, as it has been shown conclusively (Trueta 1957) that cutting off the metaphysial blood supply causes ossification to stop. The trabeculae are few in number and they are thin and weak. Slipping of the epiphysis occurs easily and contributes to deformity.

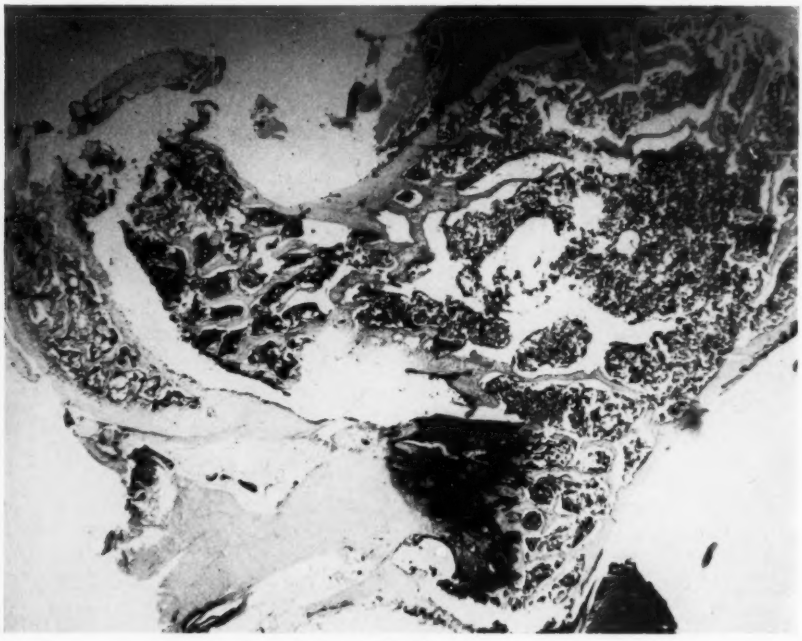

FIG. 15

A section of the metaphysis and epiphysis of a rat in group B showing the alkaline phosphatase activity under the raised periosteum and in the metaphysis (see also Fig. 7). Note the generalised osteoporosis. (×20.)

The periosteum—The raising of the periosteum may be caused by several factors acting singly or in combination.

Bleeding—There is extravasation of blood under the periosteum, but it is uncertain whether it is due to friability of the blood vessels or whether it is the effect of avulsion of the periosteum from the bone.

Loose Sharpey's fibres—The periosteum is bound down to bone by Sharpey's fibres. These are fixed to the cortex by a cement substance and, if this is deficient, they become loose, allowing the periosteum to be pulled away from the cortex by normal muscle pull.

Abnormal muscle pull—Muscle spasm and spastic paraplegia have been reported as a predominant clinical feature of the disease in man (Anderson, Howard and Simonsen 1925; Acton 1922; Stockman 1929), but no obvious signs of paraplegia were noted in our rats.

Exostosis—The large exostoses at the deltoid tuberosity and other areas may be due to the deficiency of cement substance binding down the tendinous fibres to the periosteum and to bone. Loosening of these attachments allows the periosteum to be avulsed from the cortex, with a laying down of new bone in the direction of the line of pull.

Osteoporosis—Bone rarefaction is both focal and general. Some bones—especially the femur, scapula, sacrum and vertebrae—show severe rarefaction.

The work of Geiser and Trueta (1958) shows that osteoporosis is closely linked with the lack of transmission of muscle stresses through the bone. Detachment of the calcaneal tendon caused local bone absorption with marked changes in the vascular pattern. In rats in group B the loose muscular connections and the detached periosteum must lead to a diminished muscle pull.

Furthermore, at the metaphysis, interference with the transmission of weight and stress from epiphysis to diaphysis leads to displacement. The forces normally acting in this region which influence bony structure and density are therefore disrupted. Finally, the blood vessels, being affected, would of themselves influence bone density.

The interference with the production of cement substance is not peculiar to lathyrism. Stockman (1929) believed the changes to be scorbutic, and the resemblance of the syndrome to scurvy is striking. Alkaline phosphatase concentration in scurvy is, however, known to be low, and rats in group B showed a higher concentration than normal. In scurvy again the collagen fibres are affected, whereas in lathyrism Ponseti and Shepard (1954) saw normal fibres with the electron microscope.

Although it is unlikely that the two conditions are one and the same, there is a common link—the interference with the synthesis of cement substance.

Most are agreed that the cement substance in cartilage is the mucopolysaccharide chondroitin sulphate, but not much is known about the cement substance elsewhere.

Cortisone and compound F are known to influence the synthesis of chondroitin sulphate (Bourne 1956), and this in turn is influenced by the other hormones, chiefly by the growth hormone of the pituitary. That the growth hormone of the pituitary, and possibly also that of the parathyroid, may be involved in the changes detected in lathyrism has been suggested. The increased weight of the suprarenals of male rats (Dasler 1954) and the decreased spermatogenesis reported by Ponseti and Shepard (1954) point to an endocrine disturbance. It may be that the main effect of lathyrism is either a direct one on the suprarenal cortex, or an indirect one through the growth hormone of the pituitary. However much the local effects on the skeleton are due to an endocrine disorder, our findings show that direct vascular damage plays an important part in the disorganisation of the epiphysial cartilage.

CONCLUSIONS

The main findings in this experimental work on rats fed on lathyrus odoratus (sweet-pea) meal are as follows:

1. Growth is retarded.
2. The growth plate is disorganised and normal ossification at the metaphysis is interfered with.
3. The small blood vessels are seriously affected and probably contribute quite largely to the disorganisation and lack of calcification.
4. Alkaline phosphatase activity is increased.
5. Raising of the periosteum and laying down of new bone result in exostoses.

The possible underlying etiology and the role of cement substance, endocrine factors and the blood vessels are discussed.

We wish to thank Professor J. Trueta for his unfailing advice and encouragement in our work, and for all the facilities he placed at our disposal.

This work was done with the co-operation of Mr D. W. Charles and of Mr A. Mann, to whom we express our thanks.

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IN MEMORIAM

EDWARD CHARLES BELL JONES

1900–1959

If it were written that Edward Charles Bell Jones was born on June 24, 1900, in Ivanhoe, Melbourne, Australia; that he qualified medically at Melbourne University in 1923; became a Fellow of the Royal College of Surgeons of England in 1930; graduated M.Ch.Orth. Liverpool in 1934; and practised orthopaedic surgery of a very high standard in Ipswich from 1937 until his sudden unexpected death on May 10, 1959, the reader's knowledge of the man himself would be less than could be learnt of someone's personality by looking at a radiograph of his skeleton. To evoke a living human picture is difficult even for a word conjurer, and quite beyond my power: so probably only those who knew Bell Jones will be able to convert these words into a live memory. For his qualities were spiritual and hidden, and in consequence easier to feel than to describe. He was undoubtedly a great man, and no one could meet him for long without being influenced for the better. He holds a proud place in the ranks of great Australians who have served and are serving this country so well. Perhaps appreciations by those who knew Bell Jones well may best convey something of the man whose memory we wish to preserve.

F. C. D. writes: " He was essentially honest in his whole approach to medicine, and could not tolerate anything approaching insincerity or hypocrisy. It was his insistence on straight thinking and clear understanding which made him such an excellent postgraduate teacher. He had an encyclopaedic knowledge of the literature and practice of orthopaedic surgery, and his keenly critical brain enabled him to sift the wheat from the chaff very effectively. Amongst his most endearing qualities were his sense of humour, his love of life and his affection for his fellow men . . . yet he was surprisingly humble, and in consequence his remarkable ability was evident to only a comparatively limited circle."

R. M. writes: " There are many young orthopaedic surgeons, now practising in different parts of the world, who have passed through ' B. J.'s ' hands. His recent death will have saddened them all, who have lost not only a magnificent teacher, but also a true friend. Although reticent in official publication, Bell Jones was surely among the greatest of orthopaedic teachers. Memories crowd in of his crystal-clear demonstrations of physical signs, his bold and forthright principles of treatment, and his utter condemnation of careless and inefficient work. He was really a very sentimental man, but he would hide his feelings at all costs. He hated to be complimented or thanked. One grew gradually to apprehend the warmth of his personality, so that his friendship, when achieved, was deeper in consequence. ' B. J.' was a fine and vigorous exponent of the art of orthopaedics; a brusque but sensitive and cultured man. We salute his passing, too soon for any of us to bear without great sorrow. To Mrs Bell Jones, whose house and hospitality were always open to us, we extend our deepest sympathy."

R. S. G. writes: "As a teacher he was unusually attractive because of the peculiarly earnest and confidential manner in which he imparted his information or advice. . . . The student had a sense of privilege in listening to what he had to say."

D. W. writes: "I think that in his work the qualities I would stress were essential honesty and dislike of all humbug and pretence. A day with Bell Jones in his hospital was as exciting as it was exhausting: starting early in the morning, he would finish at about 9 p.m. and then nothing would delight him more than to sit chatting far into the night. He was at his best on these informal occasions when the conversation would range from the latest orthopaedic venture on spine, or hip, or what you will, to fishing, sailing or medical politics: the whole interspersed and illustrated vividly with tales of the Australian backwoods or the Suffolk countryside."

The Lord Bishop of St Edmundsbury and Ipswich, the Rt. Rev. Harold Morris, D.D., in his address at the memorial service on May 20, said: "Today, at this service, we have met to pay honour to Edward Bell Jones, a great orthopaedic surgeon who brought honour and distinction to his profession and to the town of Ipswich and county of Suffolk where he worked with the greatest devotion for twenty-two years. I count it a privilege in the name of all here present to be called upon to pay a tribute of gratitude and affection to him. When I was gathering impressions about his character a great friend and close colleague described him as a man of great tenacity, who stuck to his guns and worried till he achieved his purpose—a very hard worker of whom it could be said that he gave his life for others and wore himself out in the service of his fellow men. He gave his life for others as certainly as the man who dies on the field of battle in the service of his friends; and we are all the poorer because Bell Jones has been taken from us."

It would be a bold and foolish man who tried to improve on these words. In all of them the same theme can be discerned, and the question why he so combined a love of perfection, a devotion to realism, an affection for his fellow men and an intense burning desire to do good, intrigued me. The answer lies in a sentence of a letter from his widow Jocelyn. "His first love was Art, second the Church, but he decided Medicine was the best after all." So now I know why so many different people felt so similarly about Bell Jones, and why we remember so clearly his warm heart, his sure touch, his keen discrimination and his vitality so intense that it was exciting to know him. He was an artist dedicated spiritually to a profession.

B. L. McF.

THOMAS LABATT LAWSON

1913–1959

Mr T. L. Lawson, consulting orthopaedic surgeon to the Beckett Hospital, Barnsley, and to the King Edward VII Orthopaedic Hospital, Sheffield, died suddenly at his home at Worsborough Dale, Barnsley, on May 14, at the age of forty-six.

Thomas Labatt Lawson was born in Dublin of Irish Huguenot parents. He was educated at Trinity College, Dublin, graduating B.A. in philosophy in 1937 and M.B., B.Ch., B.A.O. in 1938. In 1940 he took the D.T.M. & H. (Liverpool), and in 1945 the F.R.C.S. (Edinburgh) and the M.Chir. (Dublin). After holding several house appointments he entered the Colonial Medical Service and served as a medical officer in Uganda. He was then appointed to Nigeria

and became lecturer in othopaedic surgery at University College, Ibadan. He was largely responsible for the organisation of the orthopaedic services in Nigeria, and the development of orthopaedic surgery in that country is in great measure due to his energy, tact and skill. Those who visited him in Nigeria were greatly impressed by his work in difficult circumstances. Nine years ago he was invalided out of the Service and returned to Britain, where he was appointed consultant orthopaedic surgeon to the Beckett Hospital, Barnsley, and to the King Edward VII Orthopaedic Hospital, Sheffield. At Barnsley he devoted his great energy and ability to the development of a comprehensive accident and orthopaedic service. The excellence of this department will be a lasting memorial. He was a member of the British Orthopaedic Association and a much loved member of the Yorkshire Orthopaedic Club.

Tom Lawson was a delightful man, full of Irish charm and wit and with great ability. He had wide interests, and was particularly fond of sailing and of all country pursuits. His colleagues in South Yorkshire had the greatest affection and respect for him. His patients adored him. We all grieve at the loss of a devoted surgeon and loyal friend, and extend our sympathy to his widow and his two daughters.

F. W. H.

LENNOX GRAHAM TEECE

1889-1959

All members of the Australian Orthopaedic Association were shocked to read in the press of the sudden death in his sleep of Mr Lennox Graham Teece while touring in France with his wife.

He had not been very fit for some years and consequently had given up skiing and golfing, but he continued to enjoy the races. I met him over twenty-five years ago while on a skiing holiday at Mount Kosciusko with the Australian Ski Club. Lennox, one of the senior members, was at that time a great leader of touring parties on the Main Range of the Australian Alps. His tall athletic figure was invariably in the lead, and the pace set was one which even beginners could follow. He learned his skiing in the days before the Aarlberg technique became popular, and no one at that time could execute a nicer telemark turn. Apart from his tirelessness he was so considerate of young inexpert tourists that each trip was a great success and enjoyed by all. During his winter holidays in Australia, and on occasion in New Zealand, he came in for much work in treating the injuries of this sport. This he did with efficiency and charm. He was a keen member of the club in evenings at bridge or poker, which he played very well. As an after-dinner speaker he was without a peer, not only in the ski club, but in the Australian Orthopaedic Association. With all his qualities it is natural that we remember his period of presidency as one of the most successful.

Lennox became interested in orthopaedics during the first world war, when he became associated in the Military Orthopaedic Hospital at Shepherd's Bush with Sir Robert Jones, McCrae Aitken and Naughton Dunn. On returning to Australia he decided to confine his practice to orthopaedics, and he was appointed Orthopaedic Surgeon to the Royal Prince Alfred Hospital, a position he held until he retired. Lennox was therefore one of the pioneers, if not the pioneer, of orthopaedic surgery in Australia. He soon developed a large practice in addition to his work at the Royal Prince Alfred Hospital. No one, I believe, in Australia has operated on so many internal derangements of the knee joint. Because of his brilliant mind and ready wit his practice in medico-legal work became enormous.

Throughout his life his home was very happy and, like the Island in Mary Rose, it "liked to be visited." His dogs, Rudolf and Hansel, continue to look out for him about the time he usually arrived home from work. To his widow Allison, his son and daughter warm sympathy is extended.

J. B. C.

J. H. writes: "I am indebted to Mr Eric Fisher, who knew Lennox Teece well at school and during his university career, and who delivered the memorial oration in St Stephen's Church, Macquarie Street, Sydney, soon after the sad news of his death reached us.

"Lennox Teece graduated in 1913, top of his year at the Sydney University, and became Resident Medical Officer at the Royal Prince Alfred Hospital; Senior House Superintendent following Harry Clayton when he went to the war. Soon after Lennox journeyed to England, and joined the Royal Army Medical Corps. On his return to Australia he was appointed Director of the newly established Department of Orthopaedic Surgery at the Royal Prince Alfred Hospital, in which position he remained until he reached the retiring age.

"In October 1936 a meeting of ten surgeons interested in orthopaedic surgery was held to discuss the advisability of forming an Association of Orthopaedic Surgeons. E. B. Vance was voted to the chair, and when the Australian Orthopaedic Association was formed he became the first president. Lennox was, of course, a foundation member, and remained active until his departure on the ill-fated trip abroad in February 1959. He filled various offices in the Association, and became its President in 1953. His contributions to discussions were always to the point, and frequently enlivened by flashes of his well known native wit, which made him a welcome after-dinner speaker.

"Apart from his professional work he was one of the best known ski runners in New South Wales. He became interested in the sport when Resident Medical Officer at the Royal Prince Alfred Hospital, and he took a turn as medical officer at the old Hotel Kosciusko. His colleagues of the snow speak of his unexpected toughness on long trips. Quoting from Eric Fisher: 'He was long, lean and leathery and finished as fit as anybody.' Among his other interests were racing—he attended most of the meetings at Randwick—and bridge and poker, at which he played a good hand. The news of his death came as a bomb to most of us, who were unaware he was not in his normal health. He is greatly missed."

H. C. B. writes: "Lennox Teece graduated at Sydney University in 1913, and soon afterwards became Assistant Medical Superintendent of the Royal Prince Alfred Hospital. He was rejected for war service with the Australian Army Medical Corps, but later went to England and joined the Royal Army Medical Corps. As a young medical officer he was directed to the Army Hospital at Shepherd's Bush and there came under the influence of Sir Robert Jones and the team of young orthopaedic surgeons that were working with him. One who appealed to him in particular was Rowley Bristow. He remained at Shepherd's Bush for eighteen months, and soon became absorbed in the problems of war wounded. On his return to Australia in 1918 he had made up his mind to specialise in orthopaedic surgery, and he was put in charge of a new department at the Royal Prince Alfred Hospital. He was followed home soon afterwards by Denis Glissan and Arthur Meehan. These three were the pioneers of orthopaedic surgery in Australia, and all three have now passed on.

"He was a Foundation Fellow of the Australian Orthopaedic Association and of the Royal Australasian College of Surgeons, and he became President of the Association in 1953. He contributed articles on a variety of orthopaedic subjects, including tendon injuries, club foot and lesions of the shoulder and of the knee. His main interest lay in disorders of the knee joint, and he chose this subject for the first Meehan Memorial Lecture in Brisbane in 1956. This was based on two thousand meniscectomies. He devised a test for the detection of posterior horn tears in semilunar cartilages that has been widely adopted in Australia. Apart from a large private practice, he developed almost a monopoly over workers' compensation work in Sydney for many years. He had the gift of clear concise expression, both in his written reports and also when giving evidence in court. It was often felt that he could have graced the bar table as easily as the witness box.

"Away from his work he had many interests including skiing, tennis, golf, surfing and racing. His clear thinking, good humour and quick wit were assets at meetings of the Australian Orthopaedic Association and his after-dinner speeches on such occasions will remain memorable events for many years to come."

PROCEEDINGS AND REPORTS OF UNIVERSITIES COLLEGES, COUNCILS AND ASSOCIATIONS

GREAT BRITAIN

UNIVERSITY OF GLASGOW

CHAIR OF ORTHOPAEDIC SURGERY

We are very pleased to learn of the creation of a Chair in Orthopaedic Surgery at the University of Glasgow, and more particularly that this will be filled by Roland Barnes, creator of the University Department of Orthopaedics.

Mr Barnes was educated at Manchester University, where he took his B.Sc. in 1927 and M.B. in 1930. He early marked himself out by winning both the Medical and Surgical Prizes in his final year. He filled the usual resident posts at his teaching hospital, and, as surgical registrar, he came into contact with Sir Harry Platt, who had just been appointed Orthopaedic Surgeon to the Manchester Royal Infirmary but was as yet without a department. Stimulated by this dynamic personality, Mr Barnes became interested in orthopaedics, and after a year as Resident Surgical Officer had no doubt about his career. Awarded the Dickinson Travelling Scholarship of his University, he studied for a year in the United States of America, chiefly at the old Hospital for the Ruptured and Crippled, which had recently come under the inspiring leadership of Philip Wilson. In 1937 Barnes succeeded Osmond-Clarke as Sir Harry Platt's first assistant, and he remained at Manchester until, soon after the outbreak of war, he was invited to take charge of the Orthopaedic Centre being formed under the Emergency Medical Service at Winwick Hospital, near Warrington. Later this became one of the major centres for injuries of the peripheral nerves, a subject which has continued to interest him ever since. In 1943 he was appointed the first Frederick Young Lecturer in Orthopaedic Surgery in the University of Glasgow. There was then no orthopaedic department in the Western Infirmary, Glasgow, and most of his clinical work was concerned with service and civilian casualties in the Emergency Medical Services hospital at Killearn, some seventeen miles north-west of Glasgow.

After the war the service at the Western Infirmary, Glasgow, expanded rapidly, and in 1951 Mr Barnes was made reader. The casualty service came under the control of the orthopaedic department and two wards were made available; these are still used chiefly for accident surgery, and most of the elective surgery is dealt with in 170 beds at the associated Regional Orthopaedic Centre in the beautifully situated Killearn Hospital. Now a new casualty and orthopaedic department is to be built at the Western Infirmary to accommodate the University Department of Orthopaedics.

Mr Barnes's publications are well known. The most important include papers on peripheral nerve injuries, spinal injuries and bone tumours. His work is his hobby, but he is also interested in music and gardening. There is nothing he likes more than walking in the hills, a natural response in one who has spent most of his working life in Manchester and Glasgow.

Mr Barnes has the respect of us all; not only for what he has done but also for what he is: a good surgeon and good teacher, an honest man and honest scientist.

BRITISH ORTHOPAEDIC ASSOCIATION

SPRING MEETING 1959

The Spring Meeting of the British Orthopaedic Association was held in Torquay and Exeter from April 30 to May 2, 1959, in conjunction with the French Orthopaedic Society and the Belgian Orthopaedic Society. The President of the British Orthopaedic Association, Mr Norman Capener, was in the Chair, and he was assisted by Professor R. Merle d'Aubigné, President of the French Orthopaedic Society, and Professor P. Lorthioir, Past-president of the Belgian Orthopaedic Society.

Symposium on Slipped Upper Femoral Epiphysis

The pathology of slipped upper femoral epiphysis: a new concept—*Mr A. M. Rennie* (Aberdeen) did not accept that there was a simple backward slip of the epiphysis at the epiphysial plate. He had observed that when the slip was gradual the anterior surface of the femoral neck was longer than the posterior, producing an average tilt of 31·5 degrees against a normal of 10 degrees. He attributed this to diminished growth in the posterior part of the plate resulting from multiple minor traumata, to which the upper femoral epiphysis was peculiarly liable. The true slipping of the epiphysis was secondary to this. In a number of these patients, evidence of early epiphysial arrest elsewhere suggested that in these cases the epiphysial plates were unduly sensitive to compression.

An evaluation of conservative treatment in the management of slipped upper femoral epiphysis—*Mr J. Rowland Hughes* (Oswestry) reviewed a series of seventy-two hips, forty-six of which had been treated conservatively. When the displacement was minimal further slip should be prevented by internal fixation, and these hips did well. When displacement was excessive forcible manipulation was contra-indicated because of the risk of avascular necrosis. When gradual reduction was attempted it should be by mobile rather than fixed traction to avoid the risk of stiffness. Only exceptionally was any substantial improvement gained and, if necessary, the deformity should be corrected by subtrochanteric osteotomy later.

Dr Pierre Petit (Paris) reported the progress of twenty-five hips in which the displacement was gradual. Treatment was by immobilisation without any attempt at reduction. When the bone texture around the epiphysial plate had returned to normal, movement and weight bearing were allowed. If the subsequent deformity was severe it was corrected by subtrochanteric osteotomy. This method resulted in twenty-one good hips, three fair and one bad. When the slip was rapid and severe, manipulation was necessary to correct the deformity, and the position was held by internal fixation; the results were unsatisfactory.

The treatment of slipped upper femoral epiphysis—*Mr P. H. Newman* (London) discussed the surgical treatment of sixty hips in forty-nine patients. The hips were divided into three groups. 1) The position was acceptable—thirty-nine hips. These were treated by internal fixation with multiple pins, with good results in thirty-seven hips and poor in two. 2) The position was unacceptable but reducible (six hips). These were treated by gentle manipulation and internal fixation. All six hips so treated had good results. 3) The displacement was unacceptable and irreducible (fifteen hips). These could be treated by subcapital osteotomy which gave six good results, one fair and four poor; or by subtrochanteric osteotomy with three good and one fair. Because of the risk of avascular necrosis with subcapital osteotomy, subtrochanteric osteotomy was to be preferred.

Surgical treatment of slipped upper femoral epiphysis—*Mr F. C. Durbin* (Exeter) had observed eighty-one hips in sixty-three patients. Early diagnosis was important and the best results were obtained when the slip was minimal. This type of hip was treated by internal fixation with multiple pins, which gave good results. If the slip was more than 50 per cent manipulation or heavy traction led to bad results and should be avoided. A displacement of more than 50 per cent should be corrected by subtrochanteric osteotomy.

A review of slipped upper femoral epiphysis treated at the Clinique des Enfants Malades—*Dr J. Judet* and *Dr R. Judet* (Paris) had reviewed eighty-five hips. These were divided into four stages, depending on the extent of displacement. 1) The degree of slip was minimal or nil. These hips were treated by internal fixation, for which a graft was preferred to a pin. The results were good. 2) The degree of slip was less than a third. These were treated by internal fixation with graft or pins, without any correction, and the results were satisfactory. 3) The degree of displacement caused a tilt of 35–70 degrees. Most of these were treated by cervical osteotomy with unsatisfactory results. 4) The displacement was gross. In these circumstances the authors were in favour of closed reduction and internal fixation with a bone graft.

Etiology and pathomechanics of slipped upper femoral epiphysis—*Dr R. Soeur* (Brussels) said that endocrine, vascular or traumatic theories did not alone explain the etiology of slipping of the upper femoral epiphysis. The slipping could be explained on mechanical grounds. Half of the patients were overweight, and in the other half there was an imbalance between the abductor and adductor muscles. The two factors caused an increased strain on the femoral neck, causing it to bend. Because of the coxa vara there was a compression force on the lower part of the epiphysial plate. There was a corresponding stretching force on the upper part of the neck. This caused sclerosis with slowed growth below and porosis above. These factors predisposed to further slipping. If a nail was introduced into the neck it would give it support, so that the epiphysial plate would fuse even if the nail did not cross it.

Avascular necrosis complicating slipped upper femoral epiphysis—*Mr H. G. Lowe* (Cardiff) had reviewed twenty cases of slipped upper femoral epiphysis in which avascular necrosis had occurred. These were divided into two groups. The first comprised those showing increased density of the capital epiphysis, but with a good joint space. These had a good prognosis. The second group, which was the larger, showed acute necrosis of the articular cartilage, and had a bad prognosis. Four of the hips in this latter group came to arthrodesis, and at operation the cartilage on both sides of the joint was equally necrotic, suggesting that some factor other than avascularity of the capital epiphysis had caused the damage. Heavy traction, prolonged immobilisation and early osteotomy were believed to be important factors in causing this necrosis.

Professor J. Trueta (Oxford) emphasised the importance of the blood supply to the femoral head and showed injected specimens from the appropriate age which demonstrated how vulnerable were the lateral epiphysial vessels to damage at any operation on the femoral neck. *Mr F. W. Holdsworth* (Sheffield) said that the blood supply may be damaged by an acute slip, but not by a slow slip. He thought that we should consider the deformity as being between the epiphysis and the acetabulum and it should be corrected by subtrochanteric osteotomy. *Professor Bryan McFarland* (Liverpool) said that the prognosis depended on how quickly the slip occurred and how great was the displacement. A quick slip might damage the blood supply to the epiphysis, but not a slow slip however great the deformity. Treatment and prognosis were different in each case. He could not understand why, if Mr Rennie and Dr Soeur were right in their concept of the etiology, everyone did not have a slipped epiphysis. *Professor R. I. Harris* (Toronto) said that the most interesting aspect of slipped upper femoral epiphysis was its etiology. He believed that endocrines played a large part in this, and showed slides of sections of the epiphysial plates of rats which had received excess growth hormone. This had resulted in broadening of the plates which rendered them unable to stand the stress of even minor trauma. *Mr G. Gordon* (Whitehaven) noted that subtrochanteric osteotomy was coming back into favour. One of its advantages was that it increased the blood supply to the epiphysis. *Professor M. Guilleminet* (Lyons) did not think that the systematic classifications suggested were sufficiently comprehensive. He thought that there were other causes of slipped upper femoral epiphysis which had to be taken into consideration. He advised against continuing for long with conservative treatment because the deformity might increase and surgical correction become necessary, in which case the prognosis was poor. He stated that he had treated two hips with displacement osteotomy at an early stage, but it was too soon to assess the result.

Other Papers

The treatment of relapsed club foot—*Mr Dillwyn Evans* (Cardiff) described an operation for the correction of relapsed club foot. This consisted in correction of the deformity as far as possible by wedged plasters, followed by a medial and posterior soft-tissue release with elongation of the tendo calcaneus if necessary and, finally, resection and fusion of the calcaneo-cuboid joint. This operation had the advantages that growth of the foot was unaffected and relapse had not occurred in any of the thirty feet treated so far, during six years. In fact it was emphasised that in one foot in which over-correction had been obtained no relapse had occurred and the excessive valgus had to be corrected by operation. At first the tibialis anterior had been transplanted laterally, but this was not now considered necessary.

A method of resurfacing osteoarthritic knee joints—*Mr K. H. Pridie* (Bristol) had noticed that, after extensive " debridement " of knee joints in the manner described by Magnuson, the raw areas of bone became covered with smooth fibro-cartilage. Examination of serial sections of joints suggested that the articular cartilage derived its nutrition from the cancellous bone deep to it. When this subchondral bone became sclerotic the cartilage necrosed and the bare bone was exposed. If these sclerotic bone areas were drilled and the holes were not too far apart, smooth fibro-cartilage would spread over the surface. Four knee joints which were subsequently re-explored showed this to have happened,

and it was emphasised that these four were explored only because they presented the worst results; the others must have been even better. *Mr G. Gordon* (Whitehaven) said that osteotomy to correct varus or valgus produced benefit because it increased the vascularity. *Mr Pridie* agreed that osteotomy was sometimes helpful.

A method of treating defects of the tibial shaft in children—*Mr R. Owen* (Liverpool) described the management of thirteen tibial defects in children. Congenital defects accounted for four, infection and sequestration for eight, trauma for one. All were treated by bridging the gap with the companion fibula used as a live graft. Each end was implanted into the tibia at a separate stage, the blood supply of the fibula being preserved. The main points of management and technique were: 1) The age for operation was eighteen months to two years; 2) at least six months must separate the two stages; 3) length might be increased by filleting the upper end of the fibula and applying skeletal traction as a preliminary stage; 4) congenital fibrous bands might need to be excised; 5) the lateral popliteal nerve must be mobilised to avoid damage; 6) the implant should be as far from the epiphysial line as possible; 7) the ankle mortise must be preserved; 8) metal fixation should be avoided. Before operative treatment was undertaken any deformity of the foot must be corrected by manipulation.

The cause of non-union in fractures of the neck of the femur—*Mr A. J. Harrold* (London) recalled that blood shed into synovial joints such as the hip did not clot, or, if it did partly clot, the clots were removed without becoming organised. It had also been noticed that non-union of fractures of the femoral neck was absolute, there being no fibrous union. Clinical and experimental observations suggested that anticoagulant and fibrinolytic substances were present in synovial joints, and that these substances prevented the formation of an adequate clot between the fracture surfaces. These factors were probably the same as those responsible for keeping the normal joint space open. Any intracapsular fracture might be affected, but the risk would be reduced by accurate reduction.

Remarks on the surgical treatment of non-union in closed fractures of the shaft of long bones—*Dr Jean Verbrugge* (Antwerp) believed that fractures of the shafts of long bones in normal individuals should always unite. Failure to get union resulted from faulty treatment. This might be lack of immobilisation or faulty position. Non-union or delayed union were said to be present when the fracture was either mobile or painful after three or four months of treatment. The method of bone grafting that he advised consisted of freshening the bone ends and drilling the medullary cavity. An intramedullary peg of iliac bone was inserted. Solid iliac grafts were laid against two sides and fixed with encircling sutures. The fragments must then be securely fixed together by means of a plate and screws inserted obliquely. This technique had been found very efficient and numerous examples were shown.

Intramedullary pressures of the femoral head—*Dr J. S. Miles* (Denver, Colorado) (introduced by the president) recalled that many methods had been employed to try to determine avascular changes in the head of the femur before they became obvious radiologically. Among these were needle biopsy, radioactive isotopes and arteriographs. The work of Larsen (1938, Annals of Surgery, **108**, 127) and Petrakis (1954, Journal of Clinical Investigation, **33**, 27) suggested that the measurement of intramedullary pressure might be used for the same purpose. If a trocar was introduced into the normal femoral head a pressure of about 20 millimetres Hg. was obtained; it fluctuated with the pulse. If the head was avascular this pressure would not be found. If the readings were doubtful, a pressor substance might be given to the patient to raise the blood pressure: if there was no equivalent rise in the intramedullary pressure in the femoral head it was likely that the blood supply was impaired. Dr Miles thought that the method was 60 per cent accurate; the technique was still being improved.

The trochanteric reconstruction operation for ununited fractures of the upper end of the femur—*Dr Paul Colonna* (Philadelphia) said that established non-union of fractures of the neck of the femur presented a difficult problem. He had described an operation in which the head of the femur was removed, the neck was excised flush with the trochanters and the abductors were separated from the greater trochanter. The greater trochanter was placed in the acetabulum, and the gluteus medius was attached lower down the shaft. The hip was immobilised in a plaster spica with 30 degrees of abduction for one month. Exercises, at first passive and then active, were begun at four weeks and weight bearing at six to eight weeks. Films were shown demonstrating the technique of operation and examples of patients so treated as long ago as 1933.

Early diagnosis of cerebral palsy (film)—*Professor R. S. Illingworth* (Sheffield) said that the aim of this film was to show the early diagnosis of cerebral palsy by the simplest possible methods. The first indication of the spastic form of cerebral palsy was often delayed motor development. The commonest cause of this was mental deficiency, the second commonest cause was cerebral palsy. The early signs of the spastic form of cerebral palsy were increase of knee jerks, ankle clonus and adductor spasm in the thigh muscles. These signs could be detected in the first week or weeks of life. The knee jerk was tested for by tapping over the dorsum of the foot, and tapping at intervals until the patellar tendon

was reached. A brisk response over the lower part of the leg strongly suggested disease of the pyramidal tract. It was always difficult to draw the line between normal and abnormal, but the presence of ankle clonus proved conclusively that the child had the spastic form of cerebral palsy. In the older infant, after three months, the persistence of the tonic neck reflex, or of the grasp reflex, or of a persistently closed hand, indicated the spastic form of cerebral palsy. After the age of six months the spastic approach to an object, such as a cube, with the slow splaying out of the fingers, was very characteristic. The plantar responses were of little or no value until the child was over three years old.

The film began with a normal child of six weeks, showing the position in ventral suspension. Special emphasis was laid on the flexion of the arms, partial extension of the hip and flexion of the knees in a normal child in this position, whereas in a child with cerebral palsy the arms and legs often hung straight down. Thereafter eleven children with cerebral palsy of the spastic form were shown. One was photographed at four days of age, and another at five days, with subsequent records at intervals to two years in one and fifteen weeks (when he died) in another. A spastic quadriplegic was shown at ten days and eighteen months; another at six weeks, two years and four years of age. Two sets of twins were shown, one normal, one with cerebral palsy, in order to show the diagnostic features. Three children with athetosis in the first year were shown. The early sign might be merely ataxia, with athetoid movements appearing later. Two children with tremor were shown. A child with the rigid form was shown at twelve weeks and two years of age. The film concluded with an important word of warning. Rarely, a child showed defective motor development and sometimes neurological signs in the early weeks, only to lose them and grow up to be perfectly normal. Two examples were shown. A baby had a proved cerebral haemorrhage and a series of major convulsions after birth. There was severe motor retardation in the first few weeks, as shown in the film, but subsequent records showed him catching up, and finally becoming perfectly normal. Another child had complete apnoea for over an hour after birth. There was the same picture of severe retardation in the early weeks, well shown in the film, followed by rapid progress, with convincing records of the child obviously perfectly normal at one year of age. The need for great caution in giving a prognosis was the concluding point of the film.

The neurological contribution to cerebral palsy—*Dr N. S. Alcock* (Exeter) said that despite some progress in the assessment of the various factors such as the part played by vascular insufficiency, much remained to be done in the correlation of the clinical features and the pathological findings. In the neurological examination the mechanism and the extent of the defect must be determined. It was emphasised that the functional effect on the child was the result of the inter-relationship of a developing nervous system and a probably changing defect. The handicap might well alter with time, and a better knowledge of the course of the condition was needed—if only to allow an accurate assessment of the results of treatment. Some new physiological concepts were becoming necessary in the light of recent work on the control of involuntary movements by neurosurgical operations, and although these were not yet applicable to cerebral palsy they offered interesting possibilities.

The management of a heterogeneous group of cerebral palsied children—*Mr J. M. P. Clark* (Leeds) described a scheme of management that had been evolved over a period of twelve years. In Leeds, a city of half a million people, the school population in 1958 was 77,000, among which the incidence of cerebral palsy was 2·4 per thousand. Thus, a group of 189 children with various degrees of cerebral palsy had to be fitted into the school programme during the year.

The children were selected at the pre-school clinic for the available accommodation which comprised: 1) ordinary schools; 2) schools for the physically handicapped; 3) schools for the educationally subnormal; and 4) accommodation under the mental health authority.

During the time of the pre-school clinic the parents learnt about the home care of their children, and gained from contact with other parents whose problems were similar. It was important that a child should not be placed in a school of too high a standard for his capabilities, and a child who could not manage an ordinary school was given a trial in one for the physically handicapped. Of the 189 children, forty-seven were classified as ineducable. The fate of those children who attended school was the measure of success or failure. In the birth group 1932–39, of sixty-three children traced, fifty-five had left school, and of those not under the mental health authority thirty-five out of forty-four were employed, though not in skilled jobs.

The surgical treatment of cerebral palsy—*Mr G. A. Pollock* (Edinburgh) emphasised that surgery in cerebral palsy must be undertaken with caution. It formed only one facet in the whole problem of treatment, and to increase the chances of success certain rules must be observed: 1) the diagnosis must be accurate; 2) the patient must be observed over a period before operation was advised; 3) care must be exercised in selecting the appropriate surgical procedure; 4) the patient must be moderately intelligent, co-operative and eager to improve; 5) the effects likely to follow operation should be assessed by tests beforehand.

Surgery was of greatest advantage in cases of fixed deformity, and of least value with ataxia, rigidity or tremors. It was of little value in athetosis. Surgery should not be undertaken if similar improvement could be obtained by other means.

When possible, the result should be simulated by splintage before operation. Surgery should not be undertaken unless some positive advantage was to be gained. Generally speaking, operations on the lower limb, where only gross movements were required for weight bearing, were more successful than those on the upper limb, where fine movements were necessary. An exception to this was arthrodesis of the wrist. If the tendo calcaneus was to be lengthened it must be done with great care. The Eggers operation of transplantation of the hamstrings into the femur had given good results, but it was wise to leave one hamstring intact.

Treatment of cerebral palsy in Belgium—In the absence of *Dr J. Delchef* (Brussels) the president read a summary of the remarks he had wished to make. He considered that if the patients' cooperation could be gained and careful follow-up was possible, certain well tried operations were helpful. Among these were operation on the peripheral nerves of the Stoffel type, on the afferent nerve paths, and sometimes on the higher centres. He also considered that older operations on muscles and joints, such as elongation of the tendo calcaneus for spastic equinus, had retained their value.

Surgery of the foot: indications and results in cerebral palsy in the child—*Dr M. Cahuzac* (Toulouse) had found that surgery in patients with cerebral palsy was most successful in the leg. The paper described the results of treatment in 384 children with foot deformity, 131 of whom underwent surgery. The general condition of the patient must be carefully assessed before operation. If equinus could be corrected under anaesthesia a neurectomy of the Stoffel type was indicated. But if correction could not be obtained by flexion of the knee the tendo calcaneus must be lengthened. This must not be overdone. Varus, valgus and cavus were treated by tendon transplant when passive correction was possible, and by arthrodesis when it was not.

Mr K. I. Nissen (London) stressed the dangers of overlengthening the tendo calcaneus. *Mr G. Gordon* (Whitehaven) stated that the brain developed from below upwards. This accounted for the fact that spasticity was often not present at birth, but became apparent at six months of age, when the higher centres should be taking over. *Professor Bryan McFarland* (Liverpool) emphasised the importance of getting the confidence of these children, who were often exceptionally emotional, if treatment was to be successful. *Mrs D. P. Beaman, M.C.S.P.*, (Ivybridge) gave an account of recent work carried out in the Dame Hannah Rogers School which emphasised the application of neurophysiological principles to therapeutic techniques.

Radiotherapy for osteogenic sarcoma—*Dr R. C. Tudway* (Bristol) reviewed nine patients with osteogenic sarcoma treated by heavy-dosage radiation. These were compared with fifty-one patients with tumours for which amputation was carried out, and forty-one treated by palliative doses of x-rays. Those with tumours of grade I responded equally well to both methods. Proportionately fewer in grade II survived, and none in grade III. When a local cure was attempted with radiotherapy the dosage must be such that there was risk of soft-tissue damage with fibrosis and necrosis of bone. The risk of this was reduced if CO^{60} was used. A close follow-up was necessary, and on any sign of recurrence the limb must be amputated: further radiation was impracticable. When the tumour was in the leg, amputation should always be advised.

A new technique of posterior vertebral fusion for scoliosis—*Dr J. Cauchoix* (Paris) described a new technique which had enabled most of the correction obtained to be maintained. Maximal correction was obtained by means of a turnbuckle plaster and the operation was carried out through the gap in the back. The method consisted in introducing a rigid strut graft across the concavity of the primary curve, and reinforcing it with chip grafts. In nineteen patients with severe scoliosis at the cessation of growth a correction of at least 21 per cent was maintained. On average, 7 per cent of correction was lost. It was suggested that the method should be successful in younger children, and recently the author had carried out fusion at twelve years of age, when correction was easier.

Professor J. I. P. James (Edinburgh) commented on the exceptionally good maintenance of correction. He said it was also remarkable to obtain 100 per cent of sound spinal fusions in such cases. He stressed the importance of correction of the deformity before maturity. *Mr R. Roaf* (Oswestry) said that the real problem in scoliosis was the prevention of progressive deformity and he felt that a graft such as that described might act as a tether, and increase the deformity: the graft should be applied on the convexity.

Phlebothrombosis complicating orthopaedic operations—*Dr R. Tubiana* and *Dr J. Duparc* (Paris) recalled that thrombosis and embolism presented serious risks in orthopaedic work, not only to life, but also to the function of the limb. Since 1949 the authors had been studying the etiology of venous thrombosis and how it might be prevented. It was necessary first to study the incidence of the complications, and their relationship to the site and nature of the operation. The type of patient

most liable to venous thrombosis could thus be determined. Next, a series of preventive measures were tried in selected patients. Venous ligature was found to be unreliable, but the prophylactic use of anticoagulants proved effective, and harmless when used with proper precautions. By this method the incidence after operations upon the hip was reduced from 15 to 4 per cent. Recently, prophylactic measures had been extended to all patients with injuries to the limbs or spine. Although there could be no guarantee of protection, these measures offered a considerable reduction in the risk of thrombotic complications.

Congenital paralytic dislocation of the hip in children with myelo-meningocele—*Mr W. J. W. Sharrard* (Sheffield) mentioned that more mentally normal children were surviving early closure of myelo-meningocele and control of the secondary hydrocephalus with the Spitz-Holter valve. Thus, more of these children with deformities of the limbs required orthopaedic treatment. Out of 250 children, eighty had some paralysis of the lower limbs. This was classified in four groups: 1) complete paralysis below the level of T.12; 2) paralysis below L.1 or 2, with some hip flexors and adductors preserved; 3) paralysis below L.3 or 4 with strong action in the hip flexors, sartorius, adductors, quadriceps and possibly tibialis anterior; 4) paralysis of one or more sacral segments. In these eighty children, seventy-five dislocations or subluxations of the hip developed. To correct such dislocations the muscle imbalance must be corrected. Adduction and flexion deformities were overcome by open tenotomy, and this usually allowed reduction. The legs should not be widely abducted for fear of stiffness in that position. When the femoral neck was valgus it was corrected by osteotomy and internal fixation (groups (2) and (4)). In group (3) the gross muscle imbalance must be corrected by tendon transplantations. This had been accomplished by transplanting the psoas-iliacus through a hole in the pelvis into the greater trochanter, so that it would act as an abductor and extensor. Care must be taken to preserve the nerve and blood supply. The iliacus was completely reattached outside the pelvis. To correct lateral rotation the sartorius was transplanted from the inner side of the knee to the outside of the femur. Eight of these procedures had been done and the transplants had made walking possible.

Presidential address—In his presidential address Mr Norman Capener (Exeter) pointed out the close ties which had always existed between British and Continental orthopaedic surgeons, and he welcomed the French and Belgian guests who were present.

He outlined the development of orthopaedic hospitals in this country, first at Baschurch, Heswell, Alton and Stanmore, which were in line with the pioneer work at Berck. These hospitals were connected with curative workshops which Robert Jones established as an early form of retraining cripples for work.

In 1919 Robert Jones and Girdlestone first described a plan for nation-wide organisation of orthopaedic services and as a result of this a new charitable body was formed, the Central Council for the Care of Cripples. Country orthopaedic hospitals were built, and around them sprang up a network of clinics for the supervision of patients before and after treatment at the central hospitals.

Since the early days when this scheme served such a useful purpose circumstances had changed. Crippling diseases of children, which were such a large part of orthopaedics, were now relatively infrequent, whereas trauma was becoming an increasing problem. Osteomyelitis, tuberculosis and, he hoped, poliomyelitis were rapidly decreasing, whereas the degenerative diseases and problems of old age were on the increase.

These changes in the nature of our work made it necessary that we should modify our views and plan for the future. Orthopaedic units must be connected with general hospitals so that we might work more closely with our colleagues in other specialities.

Finally, the increasing number of accidents made a review of the position of accident services throughout the country a matter of increasing urgency. The Executive Committee of the British Orthopaedic Association recognised this as their special responsibility and had now approved a memorandum on this subject which would be published shortly*. The object of this was to bring to the notice of all the great urgency that existed for comprehensive planning and organisation, both in the provision of suitable buildings and in obtaining personnel, adequate both in training and in numbers, to supply a complete and efficient service.

Clinical Meeting

The clinical demonstration in Exeter on May 2 was opened by four papers: 1) Charnley "arthrodesis" of the hip, 2) McMurray osteotomy, 3) spinal fusion in cases of prolapsed intervertebral disc, and 4) recurrent dislocation of the shoulder. These papers were all accompanied by films in which the results were demonstrated in an original manner, statistics being presented by numerically related groups of patients.

* The memorandum is printed in full in this issue of the Journal.

The results of the Charnley hip "arthrodesis"—*Mr J. Piggot* (Londonderry, formerly of Exeter) reported the results of ninety-one central dislocation arthrodeses of the hip performed in Exeter since 1952. The central dislocation was carried out, but without compression. After operation a single hip spica was applied down to the ankle, and weight bearing was begun at two weeks. The spica was shortened at thirty-four days. The hip was immobilised in all for twelve weeks. There were twenty-five men and sixty-six women with an average age of fifty-seven years (fifteen to seventy-eight years). The average follow-up was three years. In nine patients femoral thrombosis developed, but in six it was on the other side. Twenty-seven patients had a pyrexia which lasted more than two weeks, for which no cause was found. Bony fusion was obtained in 74 per cent and fibrous union in 17 per cent; stress fractures occurred in 9 per cent. The incidence of complications had risen with age. In the younger patients the results were particularly satisfactory.

McMurray's osteotomy—*Mr R. H. Robins* (Exeter) reviewed the results of eighty-two McMurray's osteotomies carried out in the Princess Elizabeth Hospital. All but three patients had been traced and fifteen had died. The reasons for operation were: osteoarthritis 58; ununited fracture of the neck of the femur 19; avascular necrosis 5. Since 1951 internal fixation had been used as well as plaster. The average time in plaster, before 1951, was 116 days. Since 1951 it had been only eighty-four days. There were nine complications: three pulmonary emboli (one fatal), two haematomata, two thromboses, one urinary infection and one ileus. In all, sixty-four patients were examined. The results were based on relief of pain, the patients' own assessment, function, and Gade's mobility index. With this, some allowance was made for the fact that the hip disease was not always the limiting factor. The results obtained were: excellent 23 per cent; good 38 per cent; fair 22 per cent; poor 17 per cent. On the patients' assessment, 92 per cent were satisfied, 8 per cent were not.

Spinal fusion in cases of prolapsed intervertebral disc—*G. Blundell Jones* (Exeter) compared the results of fifty-five patients in whom the disc had been removed and a single joint fusion carried out, with fifty-two patients in which the disc removal only was done. This showed a slight bias in favour of grafting and he considered the best course was to undertake this in patients under forty, but not in older patients. Secondly, he reviewed the results of H-grafts taken from the ilium. In twenty-three patients two joints were fused, seven for spondylolisthesis. There were fifteen successes; three of those with spondylolisthesis failed. Of eighty-eight single joint fusions, 82 per cent were successful, 13½ per cent were doubtful and 4½ per cent were failures.

Recurrent dislocation of the shoulder—*Mr C. C. Jeffery* (Exeter) described a review of patients with recurrent dislocation of the shoulder treated at Exeter and Plymouth. Mr G. J. Lillie had reviewed the patients from Plymouth. Forty-two patients were reviewed, upon whom forty-three operations had been performed. Of these, five were Nicola repairs, three Bankart, thirty-four Putti-Platt and one other. Usually more than six dislocations had occurred before operation. The shortest time before operation was three months, and the longest was twenty years. There were two failures of the Nicola, none of the Bankart and one of the Putti-Platt operations. In the forty successes, the average time since operation was seven and a quarter years. The average age was thirty and three-quarter years; the oldest patient was sixty-three years, and the youngest fifteen years. There was some limitation of lateral rotation in thirty-four patients, and of abduction in six. Nineteen complained of weakness, and there was some abnormality of rhythm in thirteen patients. All the patients were satisfied with the results.

Demonstrations—At the Princess Elizabeth Orthopaedic Hospital a wealth of scientific and clinical material was presented, reflecting the interests of the staff during the past thirty years. In the scientific section great use was made of peg-boards of blackened hard-board upon which were clipped illustrations using standard shop fitters' appliances and lettering. A great variety of interests were revealed, with special emphasis upon the surgery of the hip and spine, traumatology and developmental abnormalities. There was a separate demonstration of problems in the borderlines of malignancy in cartilaginous and synovial tissues. The clinical meeting produced more than a hundred patients including the President's first patient subjected to lateral rhachotomy for Pott's paraplegia done twenty-six years ago. The problem of showing radiographs in this large group was solved by providing frames on which polythene sheets were stretched and against which films could be suspended. Also on show were exhibitions from the Devonian Orthopaedic Association, the voluntary body who pioneered orthopaedics in Exeter, the Central Council for the Care of Cripples, St Loyes' College for Rehabilitation, the Bristol Bone Tumour Registry and a fine presentation of Research into Surgical Materials by Dr J. T. Scales and his associates at the Institute of Orthopaedics, Royal National Orthopaedic Hospital.

Social events—A varied programme of social activities had been arranged by the staff of the Princess Elizabeth Orthopaedic Hospital and by the Ladies' Committee. The highlight was a garden reception by Mr and Mrs Norman Capener at Haldon Grange, where the spacious and mature grounds, with their many notable trees and plants, provided the ideal setting for a most memorable afternoon.

Part of the clinico-pathological exhibition at the Princess Elizabeth Orthopaedic Hospital.

Groups in the hospital grounds.

In the nearest group are (*left to right*): Professor E. Sorrel, Professor M. Guilleminet and Dr J. J. Herbert.

Above (*left to right*): Mr C. C. Jeffery, Mr F. C. Durbin, Mr J. Crawford Adams and Mr Norman Capener.

Left: Dr R. I. Harris and Sir Reginald Watson-Jones.

The President's garden reception at Haldon Grange, near Exeter. A view showing the magnificent setting.

A display by the Exeter Morris men.

Above: Mr W. E. Tucker and Dr Paul Colonna in conversation over tea.

Right: The President among his guests.

ROBERT JONES GOLF CUP

The competition for the Robert Jones Golf Cup was played at Churston on May 2. Twenty-one competitors took part. The cup was won by the Golf Captain, Mr W. H. Maitland Smith (Doncaster) with a score of 81 − 6 = 75, one stroke better than the runner-up, Mr Dillwyn Evans (Cardiff). Mr R. I. Stirling has been elected Golf Captain for the next two years, in succession to Mr Maitland Smith.

ELECTION OF FELLOWS, MEMBERS AND ASSOCIATES

At a meeting on April 30, 1959, the following were elected:

Emeritus Fellow—E. P. Brockman (London).

Fellows—A. F. Bryson (Kano), A. L. Dawkins (Perth), J. K. Elliott (Wellington), G. R. Fisk (Bishops Stortford), Lipmann Kessel (London), A. D. Polonsky (Johannesburg).

Members—A. Beck (Cardiff), M. S. Brett (Salisbury), J. Boyd Dunlop (Dublin), D. L. Evans (Southend), E. H. T. Hambly (London), C. J. Kaplan (Durban), J. P. Kelly (Cork), D. E. Macrae (Southampton), W. Recht (Newport, Mon.), Margaret Shepherd (Birmingham), Martin Singer (Cape Town), H. G. Stack (Brentwood).

Associates—J. A. Adams (Preston), Michael Alms (Bristol), Anatol Axer (Tel-Aviv), F. H. Beddow (Liverpool), Prakash Chandra (Liverpool), P. H. Corkery (Liverpool), R. Q. Crellin (London), J. E. Gallagher (Dublin), E. J. Hargadon (Manchester), J. M. Hendry (Glasgow), R. L. Huckstep (London), Stanley Hulman (Leeds), Alexander Katz (London), Leslie Klenerman (Oswestry), H. G. Lowe (Cardiff), Ian McKechnie (Aberdeen), D. C. MacPhail (Oswestry), G. A. Marin (London), R. M. Mason (London), J. H. Miller (Glasgow), P. J. R. Nichols (Epsom), A. O. Peters (Igbobi), A. B. Watson (Birmingham), Hanus Weisl (Liverpool), G. A. Whitefield (Glasgow).

SCIENTIFIC SOCIETIES AND REGIONAL ORTHOPAEDIC CLUBS

HAND SURGEONS CLUB OF GREAT BRITAIN AND SECOND HAND CLUB

An open meeting of the Hand Surgeons Club of Great Britain and the Second Hand Club was held at The Royal College of Surgeons of England on November 22, 1958, under the chairmanship of Sir Archibald McIndoe.

Anatomy of finger joints and their splintage—*Mr R. L. G. Dawson* (London) said that metacarpo-phalangeal joints fixed at 90 degrees would extend easily, whereas proximal interphalangeal joints splinted in the same position would not. This was explained by the anatomy of the collateral ligaments. In the metacarpo-phalangeal joint these arose from the dorso-lateral aspect of the head and passed distally along the axis of the finger. They were relaxed in extension and tense in flexion. The ligaments of the proximal interphalangeal joints arose from a larger area on the side of the proximal phalanx and spread much further over the front of the joint. They consisted of a dorsal band, relaxed in extension and tense in flexion, and a volar part in which these tensions are reversed. The metacarpo-phalangeal joint should therefore be splinted in 90 degrees of flexion and the proximal interphalangeal joint in 45 degrees of flexion, so that some degree of stretch could be imparted to each ligament. Radiographs of splinted hands demonstrated how difficult it was to achieve.

Hemi-amputation of the hand—*Mr Patrick Clarkson* (London) classified hemi-amputation of the hand into three groups: 1) **Distal hemi-amputation,** the line of section being through the bases of the proximal phalanges of all digits or proximal to this; 2) **radial hemi-amputation,** involving the thumb alone or the thumb and the next two digits; 3) **ulnar amputation,** involving one or more fingers from the medial to the lateral side. The clinical problem, given stable stumps, was the same whatever the cause of the amputation: missile wounds, industrial accidents, burns, frostbite or congenital absence. A limited number of cases of severe congenital "amputation" were reviewed but surgery was not the primary or main approach to this problem. Nevertheless, it had been worth while making a planned trial in carefully selected cases, and this had been attempted in about eight patients in the last twelve years. Radial and ulnar hemi-amputation were briefly reviewed, but the chief purpose was to describe the technique for improving function in distal amputation which was believed to be original. **Radial amputation:** Littler's technique of pollicisation of the second ray with shortening, rotation and pin fixation gave the best functional and cosmetic results. In congenital absence the introduction of

extra tissue to produce a thenar eminence was sometimes worth while. **Ulnar hemi-amputation:** This required the provision of soft tissue and bone against which the intact thumb could oppose, which could be achieved by tube pedicle and bone grafting, and sometimes, although very rarely, by transferred toes. **Distal hemi-amputation:** Trunk flaps were preferred to free grafting as preserving the longest phalanx. Elongation of the thumb or other digits must be accomplished by transferring toes or, more often, by inserting iliac bone into the flap or tube pedicle covering the stumps, a method with well recognised limitations. Both the "power grip" and the "precision grip" of the shortened and mutilated hand were greatly improved if the medial component comprising the metacarpo-phalangeal joints and the stumps of the ring and little fingers could be given a greater range of flexion and radial rotatory movement. This could be achieved partly by division of the transverse metacarpal ligament and separation of the head of the fourth metacarpal from that of the third by a free graft or flap, or more effectively by resection of the distal half of the third metacarpal, combined with the establishment of pseudarthroses distally in the fourth and fifth metacarpal shafts by osteotomy.

A patient was demonstrated in whom the medial component had been mobilised by these alternative methods in opposite hands in conjunction with Mr George Bonney.

Bilateral distal hemi-amputation of the hands—*Mr George Bonney* (London) described a medical student of twenty-two who had sustained severe frostbite of his feet and hands. When he reached hospital in London two weeks later all his fingers were dead; a week later they were all amputated, and at the same time thoracic and abdominal flaps were raised. Further sequestrectomies were necessary, followed on the left side by excision of the third ray and osteotomy of the fourth and fifth metacarpals. The final result on the right side was an elongated thumb opposable to an elongated index finger, the medial part of the palm being immobile but reached by the opposed thumb; on the left a short but excellently mobile thumb could be opposed to the elongated index stump and the mobile medial part of the palm. The case was complicated by mild tetanus, despite full protection of tetanus toxoid and antitoxin.

A case of stratospheric frostbite—*Air Commodore G. Morley* (Royal Air Force) reported the cases of two aviators who " baled out " at a height of 56,000 feet. They descended in a free drop at about two hundred miles an hour through a constant temperature of −56 degrees centigrade to 35,000 feet, when the temperature began to rise. At about 10,000 feet their landing parachutes opened and emergency oxygen supply was automatically administered during descent. The navigator was not wearing gloves, and as he descended he noticed that his hands, although not very painful, were white and puckered and he attempted unsuccessfully to warm them by tucking them under his arms; when he landed he was unable to release himself from his equipment without assistance. He was soon seated in front of a blazing farmhouse fire where he thawed out while awaiting admission to hospital with blistered hands. He was later treated by moderate elevation of the hands while at rest but encouraged to use them as much as possible. Oxygen was administered intermittently. Two days later, when the blisters began to break, they were removed and the resulting area was treated by exposure. The fingers were now inflamed and thrombosis threatened, but this did not supervene and the hands and fingers made a complete recovery. Because of the sensitivity to cold of frostbitten areas his activities were restricted, but only four months after the mishap he returned to full flying duties.

The treatment of frostbite by rapid thawing was now in vogue and the cold therapy used during the last war did not now receive support. Oxygen therapy was considered beneficial whether physiologically sound or not. Previous similar experience had suggested that oxygen lack would precipitate frostbite that might not otherwise have occurred. In more severe cases reflex vaso-dilation was advisable and surgical intervention should be deferred because the outlook was uncertain and surgical trauma might occasion further loss.

The degloved hand—*Mr M. H. Kinmonth* (Leicester) pronounced this type of injury uncommon. Some twenty-three cases of skin avulsion from the upper extremity had been treated in the Plastic Surgery Department at Leicester during the last five years. Of these but five had involved the fingers. The mechanism was constant. The soft tissues of the limb were subjected to sudden swift traction, and if the skin alone were involved it was torn from the limb, leaving the underlying fascia and tendons covered by areolar tissue and paratenon. The tendons were rarely exposed. If there were crushing, the underlying structures also were injured. Skin replacement, in the forearm and hand proximal to the fingers, was not difficult. The avulsed skin might remain attached to the limb and be in reasonable condition. It was useless attempting to replace long distally-based flaps. The skin should be cut completely from the limb and all subcutaneous fat removed, and then replaced as a graft. Any remaining defect should be filled by split-skin grafts. The restoration of skin to the stripped finger was more difficult. The single finger was better amputated but if a number of fingers or the thumb were involved a skin covering must be restored.

An assessment of results must take into consideration: 1) the recovery of sensation; 2) stability of the flap; 3) the function of the hand; and 4) the ultimate appearance. With abdominal skin, sensation was very poor and normal discriminative sensation never returned. The stability depended entirely on the establishment of satisfactory circulation. Usually the circulation was poor, and often small areas would break down, particularly in cold weather. The range of movement of the fingers was often limited, because the hand was inevitably immobilised with the fingers in a bad position while attached to the abdominal wall. Finally, the appearance of these flaps was often grotesque, and much time might be expended in improving their appearance by thinning and, in some cases, partial replacement by split-skin grafts. In summary, treatment was prolonged and tedious and it was difficult at first to foresee the final result. Present methods produced poor results.

Posture of the thumb during activity—*Dr J. R. Napier* (London) described three relevant anatomical features. 1) *Movement*—The distal articular surface of the trapezium had its long axis at approximately 80 degrees to the plane of the palm, and the short axis was at right angles to this. Movement of the thumb in the line of the long axis was abduction and adduction, and in the short axis was flexion and extension. Medial rotation of the thumb metacarpal was strictly speaking a combination of rotation and circumduction in a medial direction. It was sometimes loosely called " opposition", but incorrectly because opposition was a function of the thumb as a whole and not a movement of the metacarpal by itself. In consequence of the special form of the joint surfaces and the arrangement of the ligaments, the metacarpal automatically swung into medial rotation when the thumb was fully abducted at right angles to the palm. This occurred in a ligamentous preparation and thus was independent of muscular action. This movement was mediated principally by the abductor pollicis brevis. The function of opponens pollicis was secondary to that of the abductor brevis, its main job being to maintain the medially rotated position of the metacarpal against resistance. The fully abducted and medially rotated metacarpal might be circumducted in a medial direction without losing any of its rotation. This in terms of functional activity meant that medial rotation of the thumb metacarpal was maintained whether large or small objects were gripped. 2) *Opposition as applied to the thumb*—This was a composite movement of abduction combined with medial rotation at both the carpo-metacarpal and metacarpo-phalangeal joints. This latter movement was variable, depending upon the length of the thumb relative to the remaining digits. In anthropoid apes, in which the thumb was proportionately very short, the movement was extensive. The abductor pollicis brevis was the most important muscle in opposition of the thumb as a whole, because it acted on both the proximal and intermediate joints. Loss of the movement at the metacarpo-phalangeal joint might not appear at first sight to be significant, but anything that detracted from perfect opposition of finger and thumb was a serious disability. Accurate opposition of the finger and thumb was the basis of precision in the human hand. Only one posture could be described as perfect opposition, namely square contact between the pulp surfaces of the two digits with fullest sensation. The ability to place the thumb and index finger in this position was a hallmark of mankind. Nearly all monkeys with thumbs could oppose them, but no living monkey or ape could oppose his finger and thumb as man does. 3) *The anatomical basis for the position of function of the thumb*—Only in the abducted or adducted position of the first metacarpal was there congruity between the appropriate parts of the articular surface when the ligaments held the thumb stable. In the mid-position, which corresponded to the position of rest of the thumb, congruity was least, the ligaments surrounding the joints were relaxed and the metacarpal could be passively rotated. Thus the thumb had two functional positions, in full abduction and in full adduction. It was also clear that the position of rest was not a position of function.

Treatment of traumatic tension ischaemia of muscle and nerve—*Mr Athol Parkes* (Glasgow) described " traumatic tension ischaemia " as a condition of swelling within a muscle compartment of a limb so gross that the enveloping fascia was rendered tense and the contents of the compartment were under considerable pressure. This might occur after injury, with or without fracture of the bones and generally of the closed type. The swelling was due to extravasation of blood and increase of tissue fluids within the muscle bellies rather than to haematoma. There was no obvious injury to a main artery, but clinically the ischaemic effects on the muscles and nerves within the pressurised compartment were very like those in Volkmann's ischaemia from arterial damage. A case was described in which there were tense swelling of the volar muscle compartment of the forearm, beginning contracture of the long flexor muscles and ischaemic lesions of median, ulnar and superficial radial nerves, but a good radial pulse at the wrist and excellent circulation in the hand. The patient was treated by the application of further pressure from a sphygmomanometer cuff inflated to 70 millimetres Hg. at the level of the swelling. Within half an hour active movements of the fingers improved and the ulnar and superficial radial nerves showed partial recovery. The cuff was then removed and the muscles and nerves rapidly reverted to their former state. Re-application of the cuff again restored partial

function; and after forty-eight hours of continuous treatment function in all structures except the median nerve had almost returned to normal and the subfascial swelling was much less tense. Removal of the cuff on several occasions resulted in deterioration in function until treatment had been continued for over a week. Thereafter progress was excellent although recovery in the median nerve was delayed for six months. Diagrams explaining the rationale of the treatment were shown. It was contended that all the blood entering the affected part of the limb through the arteries escaped through the distal capillaries and the unrestricted superficial veins, bypassing the compressed capillaries and veins within the pressurised compartment. If, however, this "escape route" were made just as difficult (by the cuff) as the route through the deep vessels, circulatory balance was restored and the capillaries and veins within the pressurised area again transmitted blood although the capillary and venous pressures distal to the cuff were much higher than normal. In the case described, earlier institution of treatment would probably have prevented ischaemic axonotmesis of the median nerve. The alternative treatment—decompression by wide incision of the tense deep fascia—was fraught with difficulties because the skin could not be closed.

Tendon rupture in the rheumatoid hand—*Mr O. J. Vaughan-Jackson* (London) had found spontaneous rupture of the extensor communis tendons a common cause of flexion deformity at the metacarpo-phalangeal joints in rheumatoid hands. These lesions were reparable. A sufferer with involvement of the wrist noticed abrupt painless dropping of the little finger followed after an interval, perhaps only of days, by similar dropping of the ring finger. If nothing were done, the middle and even the index finger might follow suit. Progression was always seriatim from ulnar to radial side. At exploration of a recent rupture the mechanism of attrition was clear. A small hole was seen in the floor of the extensor tendon compartment over the lower end of the ulna, and a bony spicule could be seen and felt on the lower end of the bone. This spicule was sometimes hidden by a valvular arrangement of the layers of tissue forming the floor of the tendon compartment, so that the holes in two or more layers only coincided at one point in the pronation-supination range. Alternatively, thickened synovial tissue pouting through the hole might mask the spicule. A recently severed tendon exhibited shaggy teased ends, but in the partly severed tendon the ulnar border was abraded where it overlay the bony spicule and the abrasion corresponded in length exactly to the excursion of the tendon. The later exploration revealed the tendon ends joined by a thin bluish white opaque strand of tissue—the "stretched rheumatoid tendon" of the text-books—but if this were dissected the round ends of the severed tendon could easily be discerned in it. Seen at an earlier stage this strand could be recognised as the collapsed tube of paratenon between the retracted tendon ends. Repair of the tendons by free graft or by transferring a proper extensor restored normal function. The lower end of the ulna must, of course, be removed. Other varieties of tendon attrition were also coming to light. "Combing out" of a wrist extensor by longitudinal movement of the tendon over a spicule on the dorsum of the lower end of the radius sometimes occurred, and attrition of flexors in the carpal tunnel on rough areas on the carpal bones was quite common. This process might go undetected until the tendon of a profundus or the flexor pollicis longus was severed, because the patient might not notice the rupture of a sublimis tendon. Rupture of profundus and sublimis in the flexor sheath of the little finger from attrition on a roughened sesamoid bone had also been seen. Finally, the mechanism of the well recognised rupture of extensor pollicis longus was identical, as a bony spicule had been observed in the floor of the groove on the dorsum of the radius.

Experiences in flexor tendon grafting in the hand—*Mr Guy Pulvertaft* (Derby) said that uncomplicated cases of division of flexor digitorum profundus beyond the level of the sublimis attachment might be treated by immediate suture. In late cases the suture was only likely to be successful close to the insertion and if there were no gross retraction of the proximal end. Thus, in most later cases, the choice lay between arthrodesis of the distal interphalangeal joint, tenodesis of the profundus tendon and free grafting. A useful result could be expected in 80 per cent of tendon grafts. For the average adult grafting was best, because of the importance of the thumb-index and middle finger pinch. For those whose work required precision he was prepared to graft any of the four fingers. Arthrodesis or tenodesis was better for the labouring man, because a quick return to work might be more important than ability to bend the distal interphalangeal joint. For children, whose future was unknown, grafting was attempted in all fingers. This major operation for a minor disability should only be undertaken by experienced surgeons. The sublimis tendon should never be removed, and a thin graft was required—plantaris, or if that were absent (30–40 per cent), the extensor digitorum of the fourth toe. For division of flexor digitorum profundus and sublimis he never sutured in "no man's land". Primary skin suture followed by a tendon graft gave 70–80 per cent success. Imperfect flexion was acceptable in the index finger, as the index-thumb pinch was more important than full flexion in this finger, and a stiffness of the index was not as great an embarrassment as of any other finger. For division of the

flexor pollicis longus, primary suture was satisfactory in the distal part of the thumb. Deep division was best treated by secondary grafting. Tendon grafting gave 85 per cent success, and the usual graft was the palmaris longus. For division of the flexor digitorum profundus and sublimis in the palm, both primary and secondary suture succeeded. Cross union might occur if both tendons were sutured at the same level; so profundus only should be repaired, or action would be limited to that of sublimis. If retraction had occurred, the gap in the profundus could be filled in with a sublimis graft.

For tendon grafting, the palmaris longus, fourth toe extensor and plantaris tendons were used. He no longer advocated removal of much paratenon with the tendon, except in cases of excessive scarring. Palmaris longus was pulled out through two transverse incisions. Extensor digitorum longus was dissected. Plantaris was found medial to the tendo calcaneus and freed as far up as possible. The upper end was found under the edge of the gastrocnemius, beneath the deep fascia, through an incision three fingers' breadth behind the medial border of the tibia, at the level of the greatest girth of the calf. This gave enough for two grafts. His incisions followed standard practice. The nerves and vessels were left in the anterior flap in digital incisions. The theca was removed except for three pulleys in front of the metacarpo-phalangeal joint, the centre of the proximal phalanx and the centre of the middle phalanx. If the theca were severely damaged, bowstringing would occur unless new pulleys were made with a short length of graft. Single strand stainless steel wire (·0046 inch) was used. The proximal end of the graft was joined first, with an interlacing suture, to the profundus tendon. The junction was wrapped in the lumbrical muscle. The sublimis tendon was cut short. A transfixion needle was used to hold the tendon while the suture was performed. The distal end was fixed with a Bunnell suture or by passing the graft through a transverse tunnel in the base of the distal phalanx and suturing it to itself. The tension must be such that the digit was slightly more flexed than in the usual position of rest. Haemostasis was obtained at the end of the operation by elevation and firm pressure until haemorrhage ceased after release of the tourniquet. Results showed little difference whether there were early movements or splintage. His present practice was three weeks' splintage in moderate flexion. He did not operate on children younger than three years of age. Absence of growth during the waiting period posed some difficulties, but thin graft or reconstructed pulleys or use of a sublimis motor from another finger might be used to overcome this. Speaking of new injuries, Mr Pulvertaft said that a graft in an insensitive finger was useless; so nerve recovery should be obtained before grafting. One injured digital nerve could be repaired at the time of grafting. Severe joint stiffness, with flexor tendon division in a single finger, was an indication for amputation. In the mutilated hand it should be saved. Tenolysis was of value in an unsuccessful case. Exploration must be complete, and cortisone was used after operation.

Atraumatic technique and careful haemostasis were essential. Adhesions were the commonest cause of failure. Every case of divided flexor tendons in the hand was a challenge to the surgeon. Mr Pulvertaft was convinced that the most common cause of failure to secure a good result under favourable conditions was the failure on the part of the surgeon to live up to the strict and high standards that are essential to success. With regard to the complicated case, he said that indications were less strict in the mutilated hand. Restoration of only partial movement might be of great value. Severe scar contracture might require flap replacement. Linear scar contracture might be helped by z-plasty or cross-finger flap. Nerve division required suture or nerve grafting as a prelude to tendon restoration. Joint stiffening was usually due to contracture of the collateral ligaments. Capsulectomy might improve movement in the metacarpo-phalangeal joint, but the proximal interphalangeal joint presented an almost insuperable problem.

SOUTH-EAST METROPOLITAN REGIONAL ORTHOPAEDIC CLUB

A meeting was held on April 2, 1959, at the Royal Veterinary College, London, at the invitation of the members of the Royal Veterinary Society. After the president of the Society had welcomed the visitors papers were read by members of both professions, and the discussions that followed proved extremely instructive.

Osteochondritis of the hip in children—*Mr P. R. Wright* recalled that the condition was described fifty years ago and was not at first recognised as distinct from tuberculosis. The clinical course was that of a synovitis of the hip, but the radiographs were diagnostic. The diagnosis might be missed altogether, as shown by the numbers of patients between twenty-five and forty who presented without any previous history but whose radiographs showed the typical broad, flattened head, broad neck with some shortening and an established arthritis of the joint. Recent work by Trueta on the blood supply of the upper femoral epiphysis had shown that at the age at which osteochondritis occurred

the supply to the head was relatively precarious. Heredity had been shown to be an important factor in many cases, the vascular pattern in the femoral head appearing to be inherited as a Mendelian dominant.

Osteochondritis of the hip in dogs—*Mr Churchill Frost* described the condition as found in dogs. It occurred in small dogs and was almost unknown in large ones. The age incidence corresponded to that in humans and the clinical picture was similar, but both hips were much more often affected. Full function usually returned in six to eight months, but some permanent changes might occur and lead to a subsequent arthritis. Treatment was easier than in man because the pain of the synovitis automatically limited the degree of weight bearing in a four-legged animal. In resistant cases an arthroplasty might be considered. A miniature poodle was shown who had had a stainless steel femoral head replacement at the age of eighteen months (two years ago) whose function could only be described as " excellent." In discussion *Professor J. Trueta* (Oxford) said that he had recent evidence to show that in the negro races the blood supply to the femoral head through the ligamentum teres was far more substantial at the critical age than in Western European children, and Perthes' disease was practically unknown in negroes. A condition of local ischaemia from any cause for even a few hours might initiate the changes, but during the rest of the clinical course there was a local hyperaemia. *Mr H. Jackson Burrows* recalled that sickle-cell anaemia, a disease of negroes, sometimes caused changes in the epiphysis of the femoral head reminiscent of Perthes' disease.

The use of prostheses in hip surgery—*Mr T. T. Stamm* said that any material suitable for use in arthroplasty must be made in one piece, must withstand friction under load and bending strain, and must be completely inert in the body. The nearest approach at present was Vitallium or Vinertia. He outlined the principles of a new prosthesis designed to fit right across the femur at the inter-trochanteric level and promised to give further information about it at a future meeting.

Mr G. France and *Mr C. Bingold* showed a film of four successful cases of massive resection of a long bone for tumour, two involving the upper half of the femur and two the upper half of the humerus. They had used combinations of stainless steel and acrylic for prosthetic replacement, and function varied from " fair " to " excellent."

Dr J. T. Scales showed the results of some replacements of the upper half of the femur in goats. *Mr J. S. Malkin* showed some femoral prostheses for use in rabbits which were cheap, simple, and easy to insert, though they replaced only the head and none of the shaft. He was experimenting with titanium but could not yet give any long-term results.

Reactions of metallic implants—*Dr E. G. Clark* gave a lucid exposition on the formidable subject of metal reactions in living tissues. He showed that it was possible to estimate electrolytically the properties of a metal with such accuracy that only very few samples required testing *in vivo*, so that a large amount of time, trouble and expense were saved in assessing many industrial metals submitted for testing. Dr Clark also outlined the errors in technique which could initiate corrosion and tissue reaction and said that a true, 100 per cent electrolytic neutrality could not be achieved because local alterations of the pH of the tissues produced measurable electrical changes. He also agreed in discussion afterwards that his " council of perfection " applied only to long-term prosthetic implants and was of little practical significance in temporary measures such as intramedullary fixation and plating when the implant was to be removed after a period of months.

Equine surgery—*Mr J. Roberts* showed a film of an operation for the removal of a fractured vestigial second metacarpal in a race horse. The animal had previously been treated by " firing," which made the operation difficult, but the film was extremely clear and the standard of asepsis did not really require the initial apology which Mr Roberts made for it.

Fractures of lateral humeral condyle—*Major R. H. Freeman* read a paper on fractures of the lateral humeral condyle in children. He described it as a " push-off " injury with subsequent rotation of the fragment, but also thought that it constituted part of a dislocation of the whole joint in many cases, the dislocation becoming partly reduced. He suggested that pin fixation was the best form of treatment and mistrusted fixation by suture of the soft tissues. He said that the fragment often required considerable " fiddling " to get it into place: he discussed the claims for closed reduction but believed that it was seldom possible.

Mr J. Knight described the corresponding fracture in dogs. He said that there was often considerable delay in the dog's being brought for advice and that open reduction was always indicated. He agreed with Major Freeman that " fiddling " was required to get the displaced fragment perfectly in place, but thought that one screw was adequate as a rule even though the detached fragment was relatively larger than in man and the fracture crossed the supracondylar foramen.

The discussion was continued by a considerable number of members and their guests from the Veterinary Society over an excellent dinner at the Royal Society of Medicine, and the whole meeting was generally agreed to have been of exceptional interest.

EAST ANGLIAN ORTHOPAEDIC CLUB

A meeting of the East Anglian Orthopaedic Club was held at St James' Hospital, Kings Lynn, on November 29, 1958.

Hallux valgus in adolescence—*Mr A. B. King* reviewed various operations for this condition and showed patients treated by wedge resection of the metatarsal and transplantation of tendon through the metatarsal neck. His assessment was that the operation gave very little anatomical improvement but a good functional result. Various other methods were discussed but the general opinion was in favour of doing a Keller's operation including removal of the exostosis if this caused any pain.

Injury to symphysis pubis—*Mr A. B. King* showed examples of injury to the symphysis pubis. In some he had reduced the displacement and held the position by stapling; in one such case the stapling had failed, but eventually the patient was free from symptoms despite a considerable gap. He showed a young woman who had been involved in a road accident twenty-two years before and sustained a compound fracture of the femur with a persistently discharging sinus. On examination she was found also to have a six-inch separation of the symphysis. This aroused much discussion, many members believing that this was a congenital defect rather than the result of injury.

Comminuted fracture of calcaneum—*Mr A. B. King* described a case of comminuted fracture of the calcaneum which he had treated by primary subtalar arthrodesis from behind with the help of iliac chips. This gave a good functional result.

Osteomyelitis in children—*Mr K. C. Basappa* discussed the treatment of osteomyelitis in children, and stressed the need to deal with the local lesion as well as giving antibiotics in large doses for a long time. In discussion it was agreed that there was a changing pattern in osteomyelitis, and some members advocated the use of penicillin and aureomycin together.

Old injury to wrist—*Mr A. B. King* showed radiographs of a man who had had pain in his wrist and gave a history of an old injury. The films showed swelling and rarefaction of the lower end of the radius with shadows in the tumour. An arteriograph showed that it was not a very vascular tumour. On excision it was found to be a chondroma, and on section some doubtfully malignant areas were seen.

A further meeting was held at Addenbrooke's Hospital, Cambridge, on January 31, 1959.

Aneurysmal bone cyst—*Mr L. W. Godfrey* described seven patients with this condition. The tumour was vascular, and histology revealed blood spaces lined by endothelium and an occasional giant cell. Angioma would probably be a better name. The tumour, which often began in childhood, seemed to arise on the metaphysial side of the epiphysial plate, but could erode through the plate; sometimes it arose from the mid-shaft of a long bone. Among the seven cysts described, three arose in bones other than long bones—namely, clavicle, base of skull and ilium. Three methods of treatment were carried out: excision was best; if excision was impossible radiotherapy (1,500 R) was given. Curettage and filling with bone chips did not prevent a recurrence in one patient with a tumour at the upper end of the tibia.

Slipped femoral epiphyses—*Mr T. J. Fairbank* had analysed thirty cases. The patients were aged between ten and seventeen. Both hips were affected in 10 per cent, and boys predominated over girls; the girls were a little younger. Half of the children were normal in appearance; the remainder had mild Fröhlich's syndrome or were overgrown and lanky. Reduction and fixation without provoking avascular necrosis was the ideal to aim at. Closed reduction had a bad reputation, probably because of the fixation in plaster afterwards in full abduction and medial rotation. The criterion of acceptability was according to the amount of slipping that had occurred. In three patients slipping was less than one-fifth: one was treated by nailing, in another traction was applied and normal growth took place, and in a third plaster was applied but the cartilage space became narrowed. In eleven patients with slipping of more than one-fifth, manipulation and fixation with a nail was achieved. The duration of slipping bore no relation to the ease of reduction. In sixteen patients it was found impossible to reduce the slipping: seven underwent subtrochanteric osteotomy, four basal osteotomy and five subcapital osteotomy. Of these methods subcapital osteotomy produced the most perfect anatomical

results and, contrary to other surgeons' experience, narrowing of the cartilage space occurred less frequently than after any other method. Discussion of this paper produced general agreement that manipulation should not be condemned.

Radiographic appearances in neo-natal trauma—*Mr R. W. Butler* showed radiographs of an infant nine days old who had been delivered from a breech presentation with great difficulty at full term. The right knee and right shoulder showed periosteal thickening and new bone formation which passed through the epiphysial plate. Three days later there was a marked increase in the deposition of bone. Six weeks later there was complete fusion of the new bone. Radiographs at six months showed an almost normal appearance. It was considered that injury to the bones in a new born child could simulate neo-natal syphilis and it was wise to be aware of the appearances of neo-natal injury.

Correction of deformity in the rheumatoid knee—*Mr R. W. Butler* showed a patient who had a severe flexion deformity of a knee from rheumatoid arthritis, which made walking extremely difficult. The range of movement of the knee was virtually useless, in the arc from 135–90 degrees. A supracondylar osteotomy of the femur was performed to make this useless range into a useful one from 180–135 degrees, enabling the patient to walk.

Difficult fractures of lower end of tibia—*Mr A. C. Townsend* showed radiographs of the lower end of the tibia and fibula, involving the ankle joint. Open reduction and fixation by two or more screws had been used, the ideal being to reconstitute the mortise. Several excellent results were demonstrated.

"Cuckoo-spit hip"—*Mr T. J. Fairbank* described a patient with a history of two years' pain in the left hip. Movements were full, but pain occurred on forced lateral rotation. Radiographs showed a cyst in the superior acetabular region, and tomographs demonstrated that the cyst had a thin shell of bone over it. At operation a hole was made in the cyst and bubbly clear-coloured material was evacuated; it had the appearance of cuckoo-spit and microscopic examination shed no light on the pathology. The cyst was excised entire, and the patient has remained free from pain.

NORTH OF SCOTLAND ORTHOPAEDIC SOCIETY

A meeting of the Society was held at Bridge of Earn Hospital on March 28, 1959. A ward round in one of the children's wards provoked much interesting discussion, especially on congenital dislocation of the hip and the treatment of claw feet. Thereafter short papers were read.

Spinal fusion—*Mr Logan Clark* reviewed 187 operations by a modified Hibbs technique using supplementary bank bone. Refrigerated homogenous bone was used whenever available, but cadaveric bone, defatted and deproteinised, had been relied on mainly. This type of bone was found to be effective but required several weeks' further immobilisation. These fusions, carried out for various conditions, including 109 for tuberculosis, were successful in all except four cases. Because of the difficulty of interpreting the radiographs, secondary exploration of the fusion area was performed in 108 cases. This was found to be a trouble-free procedure giving certain knowledge of the state of fusion and obviating the need for post-operative splintage. There were no deaths from operation. In the tuberculous patients only the affected vertebrae were fused, and there was no local recurrence. In discussion, *Mr N. G. C. Hendry* said that a secondary exploratory operation was unjustified; he preferred a more limited type of fusion, using mainly the spinous processes. *Mr J. Hutchison* believed that exploration was necessary in cases of spinal tuberculosis because it gave positive proof of healing of the local disease.

Cranio-cleidal dysostosis—*Mr R. D. Muckart* reviewed six fresh cases of cranio-cleidal dysostosis that had been encountered in the past three years. Not all the patients showed the typical skull and clavicular changes. Two were referred because of palpable swellings in the region of one clavicle, and the dysostosis was confined to the middle third of the bone. Two were referred because of faulty posture. These were a brother and sister, and were found to have identical clavicular lesions with absence of the outer half on both sides and minor skull changes with wormian bones at the suture lines. The fifth patient showed the fully established picture of cranio-cleidal dysostosis. Changes were present in the skull, clavicles, spine, pubis, hips, hands and feet. The literature on the subject was reviewed. The sixth case was a rare type of cranio-cleidal dysostosis with dense, fragile bones. Only three cases of this type had previously been described in the literature. *Mr C. S. Campbell* described a further case with lesions affecting the teeth, clavicles, hips and pubis.

NEW ZEALAND

QUEEN'S BIRTHDAY HONOURS

Orthopaedic surgery in New Zealand was honoured in the Queen's Birthday Honours of June 1959, when a knighthood was conferred upon Alexander Gillies of Wellington.

Sir Alexander was the founder and first President of the New Zealand Orthopaedic Association. He attended the University of Otago for a short time, during which he represented the University at rugby football. Later he studied and qualified at the University of Edinburgh; his interests were early attracted to orthopaedic surgery, and drew him to Liverpool. After this he served as First Assistant in the Orthopaedic Department at the Mayo Clinic, and as Assistant General and Orthopaedic Surgeon at the Lockwood Clinic, Toronto, but his main working life has been spent as senior Orthopaedic Surgeon to the Wellington Hospital.

SIR ALEXANDER GILLIES

Outside his professional life Sir Alexander's activities in the public interest have been notably effective. He served in 1940 and 1941 as honorary overseas commissioner for the Order of St John and the New Zealand Red Cross Society, and has been for many years President of the latter. He was a leading foundation member of the New Zealand Crippled Children's Society, and President of the Wellington Branch.

Golf is his main recreation. He presented the Gillies Cup to the New Zealand Orthopaedic Association for annual competition, and on several occasions the donor has been narrowly headed off from winning his own cup.

Sir Alexander has travelled widely, and the honour accorded him will be appreciated by his many friends both in New Zealand and elsewhere.

NEW ZEALAND ORTHOPAEDIC ASSOCIATION

The annual meeting of the New Zealand Orthopaedic Association was held at Palmerston North and Wanganui on October 15–17, 1958, under the presidency of Mr H. Walden Fitzgerald.

Sites of election for amputation—*Mr Allan Macdonald* (Auckland) said that, from his experience of the 1,400 amputees registered at the Auckland Limb Fitting Centre, he had wondered if the classical sites for amputation were always the best. The virtue of Syme's amputation in the male patient was unquestionable. He had under his care five patients with through-knee amputations, all end-bearing satisfactorily after many years. In the upper extremity he doubted whether the sites of election had any standing. He was reluctant to amputate any part of a remaining arm stump without good reason. The aim was to produce a painless, healthy stump. In the after-treatment of arm and leg stumps he stressed that firm bandaging and active exercises were all that was needed. He advocated limb fitting as early as possible. *Mr Kennedy Elliott* (Wellington) stressed the importance of preserving the calcaneum and talus—with fusion of the joints if necessary—in amputations for hopeless club foot. *Mr Leslie Will* (Christchurch) emphasised the necessity for preserving the tibialis anterior in forefoot amputations.

Accessory ossicles of the foot—*Mr W. A. J. Pike* (Auckland) described the various situations in which accessory bones were found and discussed the clinical features of the commoner ones.

Excision of metatarsal heads in rheumatoid claw toes—*Mr H. B. C. Milsom* (Tauranga) described an operation consisting in excision of a large wedge of skin from the sole together with all the metatarsal heads. It was of particular value in patients with severe clawing of the toes and painful callosities in advanced rheumatoid arthritis. The foot was slightly shortened but the toes were restored to more normal position. He had found it more acceptable to patients than ablation of the toes.

Operative procedures in cerebral palsy—*Mr G. A. Q. Lennane* (Wellington) said that surgery should be used only in spastic cases and not in those with athetosis. He had found no permanent benefit from obturator neurectomy or posterior tibial neurectomy. Adductor tenotomy and elongation of the tendo calcaneus were of proven value.

The progress of orthopaedic illustration—*Mr A. W. Beasley* (Wellington) said that the illustration of orthopaedic conditions could depict 1) structure both normal and abnormal, and 2) treatment both operative and conservative, including equipment; it could also record events and create atmosphere. He reviewed the various styles from 3000 B.C. to those used in modern text-books and journals. He thought that the grant of arms of the British Orthopaedic Association, with its reference to Hippocrates, his ladder and the scamnum, the illumination of the Middle Ages and the crooked tree of Andry, served to remind us that orthopaedics has very deep roots.

Workers' Compensation in Australia—*Mr W. Hugh Smith* (Sydney) reviewed the Workers' Compensation Act as it affected the injured workman in Australia. While arrangements differed in the various states, insurance of workers was compulsory in all.

Some problems of coxa vara—*Mr R. H. Dawson* (Palmerston North) discussed three cases in children due to infection, ununited fracture, and cranio-cleido-dysostosis. He had not been able to maintain correction and the deformity had recurred in all three. The discussion which followed suggested that no real solution for infantile coxa vara had been found.

Staphylococcal arthritis in patients receiving steroid therapy—*Mr O. R. Nicholson* (Auckland) said that it was well known that patients being treated with cortisone and its derivatives were more susceptible to infection. The widespread use of steroids in such conditions as dermatitis could be complicated by the appearance of staphylococcal arthritis. Its course was modified and treatment might present difficulties. He mentioned three patients receiving long-term cortisone therapy who had developed staphylococcal lesions of the wrist, the shoulders and the atlanto-axial joint respectively.

Nerve root pain—*Mr Anthony James* (Dunedin), introduced by the president, described a mixed spinal nerve root. He emphasised the importance of the recognition of nerve root pain in the early diagnosis of compression of the spinal cord and cauda equina. A survey was made of some 110 cases of spinal cord compression, caused by a variety of lesions, which had passed through the neurosurgical unit of the Dunedin Public Hospital in the past ten years.

DENMARK

DANISH ORTHOPAEDIC ASSOCIATION

In 1958 the Association started Instructional Course Lectures in connection with the scientific meetings. At the meeting of the Association held in Copenhagen in May 1958 *Dr Henning Anderson*, a paediatrician with interest in endocrinology and bone dystrophy from Dr Louises Børnehospital, Copenhagen, gave an instructional course lecture on "Bone dystrophies," and *Dr Johs. Meyer*, chief of the department for bone and joint tuberculosis at the Finsen Institut, Copenhagen, and of the coastal hospital at Refsnæs, discussed "Treatment of bone and joint tuberculosis." His assistant, *Dr Konrad S. Jørgensen* (Copenhagen) and *Dr Aage Ladehoff* (Copenhagen) gave statistical information of the diagnostic methods of biopsy by drilling the vertebral bodies, and by removal of regional lymph glands.

Diagnosis of lesions of the semilunar cartilages—*Dr J. Saugmann-Jensen* (Copenhagen) had operated upon 300 knee joints at the Orthopaedic Hospital, Copenhagen, for symptoms of a lesion to a semilunar cartilage. Acute cases were seldom referred to the orthopaedic departments. Most patients had had symptoms from one to twelve months before operation was performed. He had found at operation a lesion in 83 per cent (positive cases), and no lesion in 17 per cent (negative cases). Forty normal cartilages were removed. Concerning diagnostic features of the history, he had found pain in all cases, instability on weight bearing in 15 per cent of the positive cases and in 10 per cent of the negative cases, and locking in 42 per cent of the positive cases and 35 per cent of the negative ones. Injury was reported in 95 per cent of the positive cases and in 85 per cent of the negative cases; one patient in four took part in sporting activities in the positive as well as in the negative group. Concerning objective diagnostic signs, he had found muscle wasting in 55 per cent of the positive cases, and also in 55 per cent of the negative cases. The McMurray and the Apley sign were found in 70 per cent of the positive cases and in 54 per cent of the negative cases. There was reduced mobility in 40 per cent of the positive cases and in 32 per cent of the negative cases. In 5 per cent of the positive cases there was no objective sign at all.

McBride's operation for hallux valgus—*Dr K. Jansen* (Copenhagen) had operated upon twenty-one patients with hallux valgus with thirty operations of the McBride type. All had worn a Thomsen's

brace after operation. Twenty-six operations were followed up. All the patients, except one, were satisfied with the operation. The results were grouped according to the radiographs before and after operation. The varus of the first metatarsal bone was reduced in sixteen cases. The best reduction of the valgus deformity of the toe was obtained when the sesamoid bone was removed.

Posterior approach to the hip joint—*Dr K. Jansen* (Copenhagen) described and illustrated the posterior approach, which he preferred to the usual Gibson's approach when a prosthetic replacement operation was performed.

Dysplasia epiphysialis hemimelica and dysplasia epiphysialis multiplex—*Dr K. Rechnagel* (Kolding) reported two cases. He mentioned that Trevor (Journal of Bone and Joint Surgery, **32-B,** 204) had reported eight cases, and Fairbank (Journal of Bone and Joint Surgery, **38-B,** 237) twelve cases. Altogether only twenty-eight cases of dysplasia epiphysialis hemimelica had been reported in the literature.

A further meeting of the Association was held in Copenhagen in November 1958. Instructional course lectures were given by *Dr F. Buchtal*, director of the Neurophysiological Institute of the University of Copenhagen on "Electromyography," and by *Dr Erna Christensen*, of the Neuro-medical Department of the University Hospital of Copenhagen on "Normal and pathological pictures in muscle biopsy."

Complications after local injection of hydrocortisone—*Dr Lis Zachariae* (Copenhagen) reported fourteen cases she had encountered in which local administration of hydrocortisone had led to disaster. In many of the cases a latent infection in a finger or in a joint was thought to be responsible, but also in some cases of arthrosis of the knee or hip degenerative changes were found to progress, with marginal bone resorption or necrosis. She believed that hydrocortisone was used much too often, and generally the risk involved was not realised.

Diabetic arthropathy—*Dr A. Petersen* (Ålborg) gave an account of three cases of neuropathic joints in diabetes. In two of the patients the bone destruction was localised to the foot or ankle. In the third patient the knee was involved. He had reviewed the literature and found only eighty-nine cases previously reported. In none of these was the destruction above ankle level. The three cases he reported were the first to be published in Denmark.

Congenital hypertrophy of both feet—*Dr P. Lütken* (Ålborg) described a rare case of hypertrophic growth of the anterior part of both feet. Transmetatarsal amputation was performed. The etiology was unknown; histological examination gave no evidence of neurofibromatosis.

In January 1959 a meeting was held in collaboration with the Danish Society for Rheumatic Research and the Danish Association for Physical Medicine.

Surgical treatment of rheumatic diseases—*Dr K. Vainoio* (Finland) described the various procedures performed at the Hospital for Rheumatic Diseases, Heinola. He stressed that active joint disease was no contra-indication to operation, nor was amyloidosis. He had never seen a local or general flare-up in consequence of operative intervention. For elbow deformities he performed two kinds of arthroplasty: simple resection or moulding of the bones in the manner of Haas, with interposition of a full skin graft. With interference of forearm rotation the lower part of the ulna was removed. In the foot 9 per cent of the hospital's patients had disabilities in the ankle or subtalar joints, 70 per cent in the midtarsal joints and 90 per cent in the toe joints. Most of his operations were performed on the disabled foot and included the Keller's arthroplasty and triple arthrodesis with or without bone grafts after the manner of Grice. For locking of the knee joint a "débridement" of the joint was performed. Severe effusion with little articular destruction in the knee was treated by subtotal synovectomy. Lateral instability of the knee, he thought, could be helped by a reconstruction of the ligaments with strips of full-thickness skin grafts. A severe flexion contracture with some preserved mobility he corrected by an osteotomy. He had no experience of arthroplasty of the knee; in severe cases he performed arthrodesis. For hip involvement osteotomy was often helpful. Bursitis and tendon sheath lesions were excised with relief of symptoms. Occasionally in a child there was indication for leg equalisation.

FRANCE

FRENCH SOCIETY OF ORTHOPAEDIC SURGERY AND TRAUMATOLOGY

DISCUSSION ON FRACTURES OF THE THORACO-LUMBAR SPINE WITHOUT NERVE INJURY

The following account submitted by Pr P. Decoulx (Lille) and Pr G. Rieunau (Toulouse), who opened the discussion, summarises French opinion on this topic, as presented to the French Society of Orthopaedic Surgery and Traumatology in October 1958.

Their report was based on a study of 396 cases, and was followed by contributions from twenty-seven speakers who quoted statistics representing nearly 1,700 cases.

The stability or instability of spinal fractures, as formulated by Nicoll in 1948, remained the basis for classification. The openers' investigations enabled them to put forward the notion of " posterior wall," a simple means, experimentally and clinically valid, of defining stability or instability. This " posterior somatic wall " is formed by the insertion of pedicles on the body of the vertebra, and the posterior face of the vertebral body represents a particularly tough zone of the vertebra. Their experiments have shown that only pressures of 600 to 800 kilograms caused compression and fractures of the spine. The idea of " posterior wall " enabled them to assess the stability or instability of a fracture simply by studying the radiographs side by side with the clinical picture.

It was agreed that the " Kummel-Verneuil syndrome " was disappearing completely, and strong words were used about it, such as " condemnation," " disappearance," " epitaph." In fact, the credit which this syndrome has enjoyed for so long was based on a double error. The names of two authors who described two completely different conditions were erroneously associated. Kummel described a progressive compression due to osteomalacia. Verneuil, on the other hand, showed that vertebral compression was frequently overlooked and discovered rather late, when their diagnosis was not always easy. Secondary compression never shows as progressive osseous deformation of the body of the vertebra. On the other hand, late exaggerated kyphosis can be due to atrophy of the discs, or localised arthrosis. This aspect of the problem is important because it governs the whole treatment of spinal fractures: the fear of late compressions has long haunted patients and doctors who seem to have taken pleasure in dramatising these very ordinary lesions.

To-day the advantages of rehabilitation are generally recognised, and most speakers, including the openers, treat large numbers of spinal fractures by rehabilitation alone. For 80 per cent of spinal fractures, immobilisation in plaster and surgery can be dismissed and rehabilitation is the only effective therapy. The predominance of muscles over bone has been recognised, and it has been said that bone lesions must take the second place in treatment.

The openers described in detail two techniques of rehabilitation: the one, a form of group therapy, as practised at the Rehabilitation Centre at Oignies, whose techniques have been practised for years; the other, corresponding to individual gymnastics, was more limited because the treatment must be carried out within a few hours instead of being spread as in rehabilitation centres.

Dr R. Cousin, of the Rehabilitation Centre at Oignies, communicated his results on functional rehabilitation; a particularly difficult problem in his case because his patients are miners, often the victims of violent injuries, for whom a return to work presents special difficulties. Nevertheless, out of 316 miners with spinal fractures 87 per cent were able to resume work at the coal face, which proves that excellent results can be obtained with well applied methods of rehabilitation.

The problem of the plaster jacket was the subject of much discussion. The question " Is the displacement to be reduced? " has not been completely solved. Some are irrevocably opposed to any form of reduction, and Mr E. A. Nicoll (Mansfield, England) is unquestionably the champion of rehabilitation without reduction. His arguments carry much weight since his statistics show that 48 per cent of perfect functional results correspond to a poor anatomical reduction. In his opinion, immobilisation delays rehabilitation and reduction should never be attempted, no matter how great the angulation of the vertebral bodies: even in severe displacements, rehabilitation, if it is well carried out, must bring about a fair recovery of function, provided the fracture falls into the category of stable lesions.

On the other hand, many favour reduction if the displacement is important: "it is logical," Pr J. Judet (Paris) said "to attempt reduction." "The vertebra is an ordinary bone," Pr M. Soeur (Brussels) informed us.

All told, most speakers favoured the reduction of severe compressions: Mr Ruscoe Clarke (Birmingham), Pr J. Creyssel (Lyon), Dr J. Cabanac (Grenoble), Dr D. Camurati (Bologne), Pr J. Cauchoix (Paris), Dr E. Trojan (Vieene), believed that persistent kyphosis was the start of secondary arthrosis and advocated immobilisation in plaster whenever the displacement was important.

The plaster jacket must be applied with care and precision; it should maintain the reduction efficiently and, at the same time, be light and strong enough to permit rehabilitation. The different methods of applying the jacket were described in detail.

It should be remembered that fractures in hyperextension, rare and not very easy to diagnose, are markedly aggravated by hyperlordosis, and that one must, in this case, avoid it at all cost.

The psychological effects of a plaster jacket were the subject of interesting remarks. The psychological trauma of plaster is unquestionable, for it gives the patient the impression that it is an indispensable support and focuses his attention on the weakening of the spine. This classical

notion must be amended. According to Pr J. Creyssel, plaster can often facilitate and accelerate rehabilitation by making walking easier and movement less painful. Pr L. Pouyanne believed that the plaster jacket can give the patient the benefit of a temporary support, provided he has been warned that it is a provisional apparatus and will become useless as soon as consolidation has been achieved. Dr R. Cousin stated that patients from his collective centre who were not in plaster jackets felt a certain " therapeutic frustration."

Thus, by virtue of both its mechanical and psychological roles, plaster has kept its advocates, but all agreed that it is seldom indicated and that it is indispensable in only a small proportion of cases—about 10 per cent.

Vertebral grafting is also in regression. It is important to state this, for even in present day practice grafting is used too often—in 30 per cent of the cases assessed for spinal fracture, according to Dr Dessaint.

Evidence of bad results was plentiful. Pr R. Imbert's statistics were particularly conclusive: of two series of patients treated under the same conditions and presenting similar lesions, the patients in whom grafting was not carried out had a permanent partial disability of 22 per cent and were laid up for six months, and those who received a graft had a permanent partial disability of 34 per cent and were laid up for eight and a half months.

However, spinal grafting is not wholly rejected, and some reservations should be made. Several speakers, Pr R. Merle d'Aubigné and Pr J. Creyssel in particular, made it clear that, while they are in principle opposed to vertebral bone grafting, they concede that it could be used in exceptional cases of unstable fractures with lesions of the posterior wall and psychosomatic disorders (not more than 5 to 10 per cent).

In conclusion, opinion was in favour of undertaking vertebral grafting less often, though not of abandoning it completely; in any case, there must be careful selection of operative indications, not only according to the lesion itself but mainly perhaps according to the subject and the social position of the patient.

Internal metallic fixation was proposed as a technically satisfactory solution, although its indications are still open to question. The purpose of the operation is to fix the affected segments of the spine for about three months, until consolidation of the body has been achieved. Two metal plates, set against and bolted to the spinal processes, are used to obtain mechanical solidity. Five processes are involved if a single vertebra is fractured, and more often six if two vertebrae are affected, which is generally the case with severe lesions. Two Wilson plates are placed on each side of the spinal processes and the operation table is tilted to obtain progressively a slight degree of lordosis. The effectiveness of the lordosis can then be verified with the naked eye, and the tilting stopped if the fractured laminae or articular processes become dangerously displaced. The two plates are then bolted together, with two bolts above and two below, and care is taken that each bolt perforates a spinal process.

Vertebral grafting should be considered only for unstable fractures affecting the posterior wall or arch, in which cases Böhler's method can be dangerous, and simple immobilisation without reduction seems hazardous and must be maintained too long. For vertebral lesions which are severe and unstable Nicoll applies two grafts to the spinal processes next to the bolts. The great disadvantage, which cannot be denied, is the interference with the muscles of the vertebral grooves, which is certainly detrimental to functional recovery. In consequence, the indications of this method of treatment must be defined with great caution, and internal fixation by plates and bolts must remain an exceptional measure.

Finally, the psychological aspects of fractures of the spine, which were emphasised by the openers, engaged the attention of many speakers. Their chief features were described and their mechanism investigated: constitutional proneness, affective immaturity, or acquired neurotic disorder, sentimental or social conflicts. Reference to a psychiatrist in the days immediately after the accident was deprecated. The main thing for the surgeon is to avoid the development of psychological troubles by taking preventative measures: to calm the anxiety of the patient, to entrust him to the care of the social services at an early stage in order to rehabilitate him as quickly as possible, to avoid speaking maladroitly and making impressive diagnoses, to minimise to the patient the descriptions of the lesions and to use reassuring euphemisms such as " cracks " or " slight compression." Even the psychological approach of the social organisations could be improved. The aggravation of psychosomatic disorders by administrative difficulties is well known; very often, there is too much delay in returning to work and rates of compensation may be based on the radiograph rather than on the actual functional disability. Each patient should therefore be treated, not only according to his anatomical lesion, but also according to his age, his profession and his social position. The essential aim of our therapy is to restore function; and there, as elsewhere, we must turn to the man rather than to the lesion.

ANNOUNCEMENTS

BRITISH ORTHOPAEDIC ASSOCIATION

ARRANGEMENTS FOR FUTURE MEETINGS

The Autumn Meeting will be held in London on October 23–24, 1959. On the day before the meeting, October 22, there will be an Instructional Course, to which members of the Society of Physical Medicine will also be invited.

The Spring Meeting, 1960, will be held in Glasgow from April 7–9.

TRAVELLING FELLOWSHIPS TO NORTH AMERICA, 1960

Applications are invited from Fellows, Members and Associates of the British Orthopaedic Association for election as Travelling Fellows to visit orthopaedic centres in the United States and Canada, during a tour of approximately eight weeks (including the time of transatlantic travel). Four Travelling Fellows will be appointed by the President of the British Orthopaedic Association on the recommendation of the Executive Committee. In the election, preference will be given to senior orthopaedic registrars and to surgeons who have gained consultant orthopaedic appointments within the last few years. The party will probably leave this country in May 1960.

Twenty typewritten copies of the application should be sent to the Honorary Secretary of the British Orthopaedic Association, 47 Lincoln's Inn Fields, London, W.C.2, to arrive not later than October 31, 1959. The application should state name, address, telephone number, age, qualifications, medical school, and present appointments, together with an outline of previous experience and academic or literary achievements. The application must be supported by a referee who is a Fellow of the Association.

If any young surgeon who is not already an Associate of the British Orthopaedic Association wishes to apply he should communicate with the secretary of the Association at 47 Lincoln's Inn Fields, London, W.C.2 (HOLborn 3474), who will send the necessary forms.

HAND CLUB AND SECOND HAND CLUB

An open meeting of the Hand Club and the Second Hand Club will be held at the Royal College of Surgeons of England, Lincoln's Inn Fields, London, at 10 a.m. on Saturday, November 28, 1959, under the presidency of Mr Norman Capener. The programme will include: Dr Erik Moberg (Gothenburg), the evaluation of hand sensation; Mr G. R. Fisk (London), trigger thumb; and Mr J. N. Barron (Salisbury), Mr P. S. London (Birmingham) and Mr R. H. C. Robins (Exeter) on various aspects of hand injuries. Lunch will be provided. Further details may be obtained from Mr H. Graham Stack, 150 Harley Street, London, W.1.

AUSTRALIAN ORTHOPAEDIC ASSOCIATION MEETINGS

The 1959 meeting, at which Mr H. Osmond-Clarke (London) will participate, will be held in Melbourne from October 12–16. Final details of the meeting are being prepared by the Regional Committee in Melbourne. Enquiries regarding participation may be addressed to Mr Peter Williams, Programme Secretary, 417 St Kilda Road, Melbourne.

The meeting in 1960 will be held in Sydney, probably in July, when it is hoped that Professor Bryan McFarland (Liverpool) will be able to be present.

LA SOCIÉTÉ FRANÇAISE D'ORTHOPÉDIE ET DE TRAUMATOLOGIE

The French Orthopaedic Society, under the presidency of Professor R. Merle d'Aubigné, will hold its congress from October 6–10, 1959. The set subjects are fractures of the scaphoid bone and the lumbalgias. It is hoped that on the first afternoon an opening ceremony will be held in Professor Merle d'Aubigné's new service at l'Hôpital Cochin.

MEXICO

SIXTH NATIONAL CONGRESS OF ORTHOPAEDICS AND TRAUMATOLOGY

The Sixth National Congress of Orthopaedics and Traumatology organised by the Mexican Orthopaedic Society will be held in Mexico City from May 2–7, 1960, when it is hoped that a number of distinguished guests from abroad will be present. The main topic for discussion at the Congress will be disorders of joints. Those wishing to participate in the Congress should write to the President of the Mexican Orthopaedic Society, Dr Xavier Romo Diez, Calzada de Tacubaya 101, Mexico 11, D.F.

CORRESPONDENCE AND PRELIMINARY COMMUNICATIONS

OSTEOTOMY OF THE CERVICAL SPINE

From W. ALEXANDER LAW, the London Hospital

To the Editor of the Journal of Bone and Joint Surgery:

SIR,

In December 1957 I corrected a severe flexion deformity of the cervical spine in a male patient with ankylosing spondylitis by cervical spinal osteotomy at the C.3–4 level, using skull traction with Crutchfield calipers with resection of the ossified ligamenta flava and the neural arches, taking more bone from the lamina above than below, and nibbling outwards and upwards so as to excise the intervertebral joints, the line of bone section keeping behind the nerve roots and the intervertebral artery in its canal. This operation is comparable with spinal osteotomy at the lumbar level in patients with severe flexion deformity from ankylosing spondylitis who are so bent up that they can look only at their toes. The benefit of spinal osteotomy at the thoraco-lumbar junction in severe flexion

FIG. 1

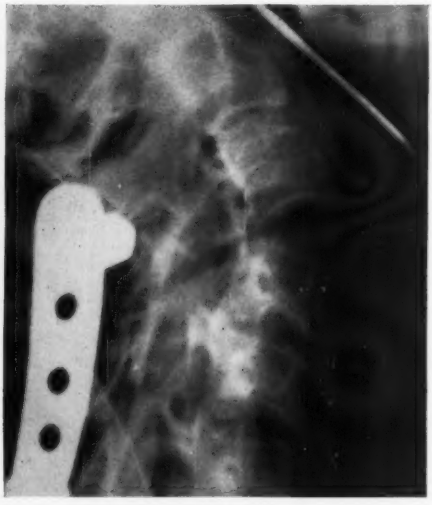


FIG. 2

deformities of the spine from ankylosing spondylitis is proved beyond doubt. It was therefore understandable that a similar osteotomy should be considered where there was severe flexion deformity of the cervical spine. The perils of cervical osteotomy are obvious. I have attempted it in two cases: the first with complete success, and the second with death at the third week after operation. The problems that arise are those of anaesthesia, nasal intubation alone being possible; of difficult respiratory exchange in a patient whose chest wall is rigid from costo-vertebral ankylosis; of tachycardia and congestive heart failure; of impairment of vital capacity over many months or years; and of general impairment of health such as to be described as a " poor surgical risk." Clearly it is premature for any surgeon to advocate spinal osteotomy in the cervical spine until further careful trials have been made in selected patients under ideal conditions, and this is intended to be no more than a most preliminary report. The two cases thus treated are summarised as follows:—

Case 1—Man aged forty-nine: clerical worker. Onset of ankylosing spondylitis in 1933, with increasing stooping deformity. Previous treatment with radiotherapy and spinal supports. The neck was fixed

rigidly in a position of flexion and rotation to the left, with the axis parallel to the ground. Cervical osteotomy at C.3–4 level with 25-degree correction was performed in December 1957. Patient walked in plaster after two weeks, was able to see ahead and felt more balanced. The improvement has been maintained.

Case 2—Woman aged thirty-three. Sanatorium treatment for pulmonary tuberculosis in 1944, with thoracoplasty five years later. Onset of ankylosing spondylitis in 1953, with marked rigid cervical kyphosis. The vital capacity was only 880 cubic centimetres. The deformity was so severe that atlanto-axial dislocation seemed imminent. Operation was undertaken at C.3–4 level with correction as shown (Figs. 1 and 2). Three weeks later she collapsed and died from heart failure. Necropsy showed that the osteotomy had caused no nerve root or spinal cord injury and that death was the result of her general debility.

Yours truly,

W. ALEXANDER LAW.

NAIL-PLATE FIXATION FOR TROCHANTERIC FRACTURES

From Mr G. K. McKEE, NORWICH, ENGLAND

To the Editor of the Journal of Bone and Joint Surgery:

SIR,

It seems that there are conflicting statements in the article by Foster on " Trochanteric Fractures of the Femur Treated by the Vitallium McLaughlin Nail and Plate " (November 1958 issue) and the one by Bremner and Graham on " Treatment of Pertrochanteric and Basal Fractures of the Femur by Immediate Fixation with a Two-piece Nail and Plate " in the same issue.

Foster suggested from studies of the bending moment that the McKee type of nail-plate had about one-fifth of the strength of the others. Bremner and Graham stated that " in no instance did the McKee nail and plate break or bend, nor did the screws lose their grip "; this was in a series of 100 cases. This corresponds to my experience over the last fifteen years. I have occasionally found that the nail has bent, but not the plate; and if the nail does bend the site at which the bending takes place is beyond its entry into the bone (Fig. 1).

The discrepancy between the experimental observations of Foster and the practical records of Bremner and Graham is probably only apparent. Both findings may represent the truth, and the explanation lies in the fact that the experimental conditions used by Foster do not usually apply to the condition encountered in the body. If the lateral femoral cortex is intact there is a strong piece of bone bridging the angle between the nail and the plate which acts like a fulcrum on the nail and converts the bending strain on the nail-plate junction into a tension strain which the metal of the plate is well able to withstand, the bending strain being on the part of the nail inside the bone beyond the fulcrum (the lateral femoral cortex) (Fig. 1). At this point let me stress the importance of inserting the nail as vertically as possible—135 degrees or more should be the aim so as to lessen this bending strain on the nail itself.

If the lateral femoral cortex is involved in the fracture, or if during insertion of the nail the lateral femoral cortex splits into the fracture line, the use of a plate with slots instead of holes is a great safeguard against the bending of the nail or nail-plate junction and consequent adduction deformity. The slots allow " take-up " of the lower

FIG. 1

McKee nail-plate. If the lateral femoral cortex is intact the nail bends beyond its entry into the bone and not at the nail-plate junction.

fragment so that impaction can take place, thus taking the strain off the nail-plate and favouring consolidation of the fracture. (In fact I prefer to use slotted plates as a routine for these pertrochanteric or basal fractures: not only do they allow this essential impaction to take place in the unstable type of fracture, but they also give a greater choice of position in insertion of the screws.)

FIG. 2

FIG. 3

McLaughlin nail-plate. Figure 2—Radiograph immediately after fixation of a fracture with a four-flanged McLaughlin Vitallium nail fixed by a stud and locking nut to the usual McLaughlin plate with an adjustable slot. Figure 3—Three months later. In spite of firm tightening the nail-plate junction has loosened and given way under the tension strain, with consequent adduction deformity.

At first the nail-plate that I introduced* was held together by a set-screw, but this was soon replaced by a threaded stud on the nail and a locking nut—an improvement which has recently been adopted in the McLaughlin nail-plate. This modification gives much greater security and can be relied upon to hold the nail and plate when the fixation hole is round (as in the McKee pattern) but there is still a risk of giving way if the hole is slotted and adjustable (as in the McLaughlin pattern), as shown in Figures 2 and 3.

Yours truly,

G. K. MCKEE.

* MCKEE, G. K. (1944): Trifin Nail and Plate for Pertrochanteric Fractures. Lancet, **i**, 143.

Book Reviews

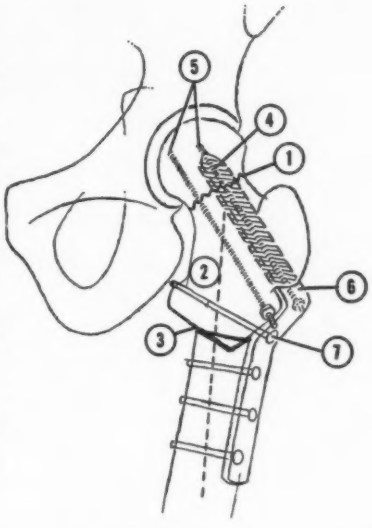
THE MANAGEMENT OF FRACTURES AND DISLOCATIONS—An Atlas. Volumes I and II. By Anthony F. De PALMA, M.D., Professor of Orthopaedic Surgery, Jefferson Medical College. $12\frac{1}{2} \times 9\frac{1}{2}$ in. Pp. xxvii+960, with 1,927 illustrations. Index. 1959. Philadelphia and London: W. B. Saunders Company Limited. Price £12, 5s.

There is a great deal to be said in favour of using line drawings instead of photographs to illustrate orthopaedic methods. That type of illustration is seen at its best in Dr De Palma's latest book. There are over 1,900 drawings to illustrate 960 pages of text. These are well set out on large atlas pages. Every conceivable fracture and dislocation, with its complications, has been included. The text is as brief as possible and is placed alongside its own illustration. Numbers on the illustrations correspond to similarly numbered paragraphs of the text. This makes the book very easy to read. Although the drawings have been kept simple, they are not entirely diagrammatic and are fairly accurate anatomically.

Postoperative x-ray
(Following angulation osteotomy)

1. The plane of fracture is now almost horizontal. (On weight bearing, stress is now a compressing force at the fracture site rather than a shearing force.)
2. The axis of the femoral shaft lies immediately beneath the femoral head, reducing leverage stresses on the hip joint.
3. The osteotomy site is immediately below the lesser trochanter.
4. The proximal end of the blade engages but does not penetrate the head too far. (This allows for further penetration of the head by the nail during the healing process without entering the hip joint.)
5. Two Knowles pins are inserted parallel to one another across the fracture site before the blade plate is introduced (Blount blade plate).
6. The blade plate is bent at a proper angle (as predetermined on roentgenograms) to place the head and neck in at least 155 degrees of valgus.
7. The most proximal screw engages the proximal fragment.

Note: No external fixation is necessary.



In his preface the author admits that he has depicted the methods which, in his hands, have yielded the most gratifying results, and that in so doing he may be criticised as dogmatic. It is therefore inevitable that individual surgeons will disagree with some of the procedures advocated. For instance, nailing fractures of the neck of the femur under *direct vision* after open reduction would not meet with universal support, despite Dr De Palma's assurance that this can be done in 20–30 minutes. This treatment is even advocated for basal fractures. Similarly, open nailing in all cases of slipped upper femoral epiphysis seems rather unnecessary. There is an unusual form of immobilisation advised for fractures of the clavicle in adults, namely a figure-of-eight bandage applied in plaster-of-Paris. It is to be hoped that the more conventional, but effective fixation with figure-of-eight bandage and sling will prevail in this country.

Dr De Palma is to be congratulated on the excellence of this book. The general layout is good and the subject matter fully comprehensive. The fact that the views expressed are dogmatic indicates that the book has been written from experience, and makes it a very valuable work of reference in every traumatic unit.—J. N. WILSON.

FRACTURES AND LUXATIONS. Diagnostic–Pronostic–Traitement: Collection publiée sous la direction du Professeur C. LIAN. By Paul MATHIEU. $8\frac{1}{2} \times 5\frac{1}{2}$ in. Pp. 212, with 103 figures. Index. 1958. Paris: L'Expansion Scientifique Française. Price 1,500 francs.

Prospective writers of text-books on trauma might well benefit from reading this excellent little book. It is a very good example of what can be done without the shiny paper and expensive reproductions so popular in most orthopaedic books today. This paper-backed monograph is really a traumatic "Penguin." It has 201 pages of information with over 100 excellent line drawings illustrating types of injury and treatment. Every common form of fracture and dislocation is described. Each condition is considered under three headings—Diagnosis, Prognosis and Treatment. There is very little to criticise. There are one or two errors in the diagrams: for instance, on page 181 the illustration of the displacement in a fracture-dislocation of the spine is the exact opposite to what is usually found,

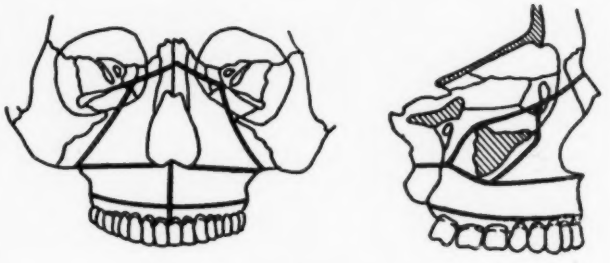


FIG. 96

Poutres de résistance du maxillaire supérieur **(face et profil)**

Trait supérieur : **disjonction crânio-faciale.**
Trait moyen : **fracture horizontale de Gūérin.**
Trait inférieur : **fracture du rebord alvéolaire.**
Trait vertical : **fracture médiane.**

and on page 138 an adduction fracture of the ankle has been wrongly labelled. In every case a sound line of treatment is indicated, and, although one might differ in the emphasis laid on certain forms of treatment, these are only differences of surgical opinion and in no way detract from the excellence of the whole book. However, some of these should be mentioned because they demonstrate the different surgical approach on the Continent. For instance, the use of an abduction frame for the treatment of a simple fracture of the shaft of the humerus is hardly the accepted method of choice in this country. Similarly, calcaneal traction for closed oblique fractures of the shaft of the tibia is not popular here. The book is essentially a guide for the medical student, casualty house surgeon and general practitioner who has to deal with fractures. For the established surgeon it could prove a useful basis for undergraduate teaching in trauma. It is to be hoped that we shall soon see an edition in English.—J. N. WILSON.

TUMORS OF THE SOFT SOMATIC TISSUES. A Clinical Treatise. By George T. PACK, M.D., LL.D., F.A.C.S., Attending Surgeon, Memorial Center for Cancer and Allied Diseases, Associate Professor of Clinical Surgery, Cornell University Medical College, New York; and Irving M. ARIEL, M.D., F.A.C.S., Associate Clinical Professor of Surgery and Associate Attending Surgeon, New York Medical College, Flower and Fifth Avenue Hospitals, New York. With fifteen collaborating authors. $10\frac{3}{4} \times 7\frac{1}{2}$ in. Pp. xvi+820, with 652 figures, 109 tables and 14 charts. Index. 1958. London, Toronto, Melbourne, Sydney and Wellington: Cassell and Company Limited. Price £11, 11s.

The present book fills a rather surprising gap in medical literature: at last we have an authoritative general work of reference on soft-tissue tumours. The senior author, Dr George T. Pack, has been associated for many years with the Memorial Center for Cancer and Allied Diseases in New York: the

book is, in fact, a commentary on a series of 717 soft-tissue sarcomas studied at the Memorial Center, reinforced by the additional experience of the senior authors and their fifteen collaborators.

An introductory section on the Classification and Natural History of Soft-Tissue Tumors is followed by sections on Principles of Treatment, Treatment of Specific Tumors, Soft-Tissue Tumors in Infants and Children, Regional Considerations, and Prognosis. The main part of the book is made up by the chapters in the section on Treatment of Specific Tumors. Here, each type of soft-tissue tumour is considered: consideration is given not only to treatment but to the definition, incidence, etiology, pathology and clinical course of each of the entities discussed. From the point of view of pathology, it is of interest that 261 of the 717 soft-tissue sarcomas reported were undifferentiated tumours which the authors described as " of undetermined histogenesis." The remaining tumours were classified as follows: liposarcoma, 105; rhabdomyosarcoma, 100; malignant synovioma, 60; Kaposi's sarcoma, 48; malignant neurilemmoma, 46; fibrosarcoma, 39; dermatofibrosarcoma protuberans, 39; and angiosarcoma, 19.

The authors stress that the first step in the treatment of a soft-tissue tumour is the establishment of correct histological diagnosis. This involves biopsy unless a small lesion can be excised whole as a first procedure. The authors are not dogmatic about the different types of biopsy that can be used, although it is apparent that they themselves have used both aspiration biopsy and open biopsy, and that they are in the habit of using frozen sections for diagnosis. Aspiration biopsy is expected to indicate only whether the lesion is benign or malignant, refinement of histological diagnosis being left until more representative material is available. The authors are hesitant about the use of open biopsy, except under tourniquet and as a preliminary to more definitive treatment of the lesion under consideration. They advocate surgery as the best method of treatment for soft-tissue tumours. They state " a major sarcoma should be removed regardless of the age of the patient provided it is technically possible and his physical state not too precarious." Radiation therapy is reserved for treatment of the inoperable or recurrent lesion. The temptation to treat soft-tissue sarcomas by local excision must, the authors feel, be resisted, except in the case of highly differentiated fibrosarcomas and liposarcomas, certain synoviomas, and a few other types of lesion. Part of the book is devoted to a general account of the surgical procedures for soft-tissue tumours, including techniques of biopsy, excision and amputation.

To the present reviewer the book is particularly valuable for its excellent accounts of certain specific types of tumour, including plantar fibromatosis, the desmoid tumour of the abdominal wall, dermatofibrosarcoma protuberans, and primary vascular tumours. It is clear that the term "synovioma" still means many things to many people. The authors draw attention to the need to specify the malignant lesion of this type as " malignant " synovioma or " synovial sarcoma," and so avoid catastrophic misunderstandings between pathologist and surgeon with regard to benign lesions. It is a pity that Jaffe's " pigmented villonodular synovitis " is not discussed in relation to synovioma.

The only criticism that the present reviewer has to make is that the authors' arrangement of the material is sometimes confusing. It might, for example, have been better to have followed a brief introductory section on the incidence of soft-tissue tumours and their classification by the main systematic account of various types of soft-tissue tumour, and to have kept until the end the accounts of the various methods of treatment and results obtained.—H. A. Sissons.

MODERN TRENDS IN DISEASES OF THE VERTEBRAL COLUMN. Edited by Reginald Nassim, B.M., F.R.C.P., Physician to St George's Hospital, and to the Royal National Orthopaedic Hospital, London; and H. Jackson Burrows, M.D., F.R.C.S., F.R.A.C.S., Orthopaedic Surgeon to St Bartholomew's Hospital, and to the Royal National Orthopaedic Hospital; Dean, Institute of Orthopaedics, British Post-Graduate Medical Federation (University of London); Consulting Orthopaedic Surgeon to the Royal Navy; with fourteen other contributors. 10×7 in. Pp. x+304, with 172 figures and several tables. Index. 1959. London: Butterworth & Co. (Publishers) Ltd. Price 75s.

This is an interesting book. At first glance one thought that there was little justification for a limited discussion of a single region of the body: surely there were no spondylologists. Yet it is true that in man's spine is the story of his origin, his evolution as an orthograde mammal from the more primitive chordate forms: the story furthermore of his present degradation as a cog of automation or as a chair-bound observer of the passing show.

The editors have assembled a notable team of collaborators; and, even though the orthopaedic editor does not himself contribute, one notices the touch of his hand in the co-ordination and skilfully achieved homogeneity of presentation. The standard is set in the brilliant first chapter by Professor R. Walmsley upon *Anatomy and Development*. His descriptions of the notochord and of the ossification

of the vertebral arch are fascinating. In the latter he exposes the fallacies of the former studies of embryological ossification which led to the view that spondylolisthesis was due to the formation of two separate ossific centres in each side of the neural arch. He discusses the anatomical basis of the weakness of the posterior part of the annulus fibrosus of the lumbar disc, and its relation to the structure and nutrition of the disc itself. This article forms an admirable start upon what the editors rightly consider to be essential, namely an up-to-date, accurate appraisal of the anatomy of the vertebral column.

The essay by R. I. Harris upon *Congenital Anomalies* follows the high standard we expect of this master, and, like his co-authors, he conveys much in a few words. He was entrusted with a large field; yet he manages to include a critical account of spondylolisthesis of which he has made a special study. Nevertheless he does not refer to the work of E. W. O. Adkins and of P. H. Newman, who both have given a certain turn to modern trends of thought in this field. Professor J. I. P. James on *Structural Scoliosis* deals in great detail with prognosis, in particular of idiopathic and paralytic scoliosis, and this covers most of the matters relating to the clinical appearances and evolution of the deformities. It forms an excellent review of the painstaking studies which for so many years he carried out at the Royal National Orthopaedic Hospital. As an essay meant for the really advanced student one finds it deficient in the techniques of treatment. Although this must be learnt by practice under a good master, a more detailed account of the author's methods would have been valuable. The article on *Degenerative Diseases* by Professor D. H. Collins is notable for its descriptions of the histology of osteoporosis and Paget's disease. On osteoporosis there is a further essay by R. Nassim devoted to the clinical and biochemical process common to so many diseases as well as the still obscure senile spondylitis. *Tuberculosis* is briefly discussed by J. A. Cholmeley: too briefly for a book which should be a guide to workers in countries where the disease is still a great problem. *Non-tuberculous Infections* are dealt with in an interesting factual article by J. A. Mantle. Dudley Hart on *Ankylosing Spondylitis* is good, but he commits the solecism of blaming an old treatment as wrong (misapplied) because it is not as good as a newer treatment; it is so easy to blame an old method when at the time of its use nothing better was known. The chapter by Valentine Logue upon *Cervical Spondylosis* gives a thoughtful appraisal of the diagnostic problems and the difficulties of surgical treatment. He finds a place for cervical intervertebral fusion, which seems to us so often neglected as a worthwhile procedure. He also emphasises the need to establish the causes of intervertebral degeneration and prevent them. *Tumours of the Vertebral Column* are dealt with by H. A. Sissons whose abstract of this subject should stimulate the reader to read the other authorities he mentions: strangely there is no mention of chondromata of the spine. Another abstract is that on *Radiology* by L. S. Carstairs, which one feels might have followed Walmsley's article at the beginning of the work, for radiology illuminates every aspect of each of the contributions. L. Guttmann's article upon the *Management of Spinal Cord Injuries* gives his well known views upon *other* methods of treatment and outlines the admirable Stoke Mandeville regime of nursing care. P. H. Newman's work upon *Low Back Pain*, in particular the mechanically unsound lumbar spine, is a joy to read; stimulating by its little divergences from orthodoxy, yet withal commonsensical: he discusses spondylolisthesis again at some length. Brief contributions are added by W. Tegner on "*Functional*" *Backache*—depressing but wise—and a discussion of *Spinal Biopsy* by N. L. Higginbotham.—Norman CAPENER.

ANATOMY FOR SURGEONS: Volume 3. THE BACK AND LIMBS. By W. Henry HOLLINSHEAD, Ph.D., Professor of Anatomy, Mayo Foundation, University of Minnesota, Head of the Section of Anatomy, Mayo Clinic, Rochester, Minnesota. $10\frac{1}{2} \times 8$ in. Pp. xii+901, with 626 figures (785 illustrations). Index. 1959. London, Toronto, Melbourne, Sydney and Wellington: Cassell and Company Ltd. Price £8, 8s.

Anatomy for Surgeons sets out to present regional anatomy in a useful and readable form for the practising surgeon. The third volume, dealing mainly with the locomotor system, is of particular interest to the orthopaedic surgeon. This volume is divided into nine sections. The first deals with general considerations, and is devoted to such topics as bone growth and structure, the mechanics of muscle, etc. The second is concerned with the back and contains a long sub-section on the spinal cord. The next four deal with the upper limb, and the last three with the lower limb. The first of the sections devoted to each of the limbs consists of a general survey. The others deal with the limb at various levels. A common layout is adopted for all the sections, and, as far as possible, the author has used the same method of illustration for corresponding parts of each section.

This is a beautiful book, extremely well made up, with clear print and good paper. The illustrations, on the whole, are excellent, being designed as diagrams to emphasise one particular point. Most are either original or taken from the author's other works. Some fall short of the mark. It is difficult to see why most sections are prefaced by a full page half-tone picture showing the superficial muscles of the part under consideration. While perfectly accurate, they do not seem to have any definite purpose; the considerable cost of reproducing them must be reflected in the price of the work as a whole, which is high. In diagrams of the origins and insertions of muscles, the origins are shown in red, and the insertions in black. This is still necessary, but one would like to get away from the idea of a muscle's having a constant " origin " and " insertion." Lines joining the two are intended to clarify the way the muscle lies, but occasionally the opposite is true: for instance, Fig. 314 (p. 436) suggests that the extensor pollicis longus lies to the outer side of the extensor pollicis brevis throughout its length, and that both are muscular almost to their insertion, and in Fig. 574 (p. 808) it is difficult to see how the tendon of flexor hallucis longus enters the foot. In conclusion, one feels that if the language were less flowery several pages could have been saved and the size of the volume reduced: for instance, on page 86 could not the phrase " The pedicles of each vertebra have a considerably less vertical diameter than the bodies . . ." have been put a little more succinctly? Nevertheless, these are small criticisms of an outstanding work which could usefully be found on any orthopaedic surgeon's bookshelf.—J. N. ASTON.

STAPHYLOCOCCUS PYOGENES AND ITS RELATION TO DISEASE. By Stephen D. ELEK, M.D., D.Sc., Ph.D., D.P.H. Professor of Bacteriology in the University of London, Consulting Bacteriologist to St George's Hospital. $9\frac{3}{4} \times 7$ in. Pp. vii + 767, with 81 illustrations in 44 figures and 22 tables. Index. 1959. Edinburgh and London: E. & S. Livingstone Ltd. Price 84s.

The author index of this book comprises about four thousand names; as a bibliography and reference book on the staphylococcus it is unrivalled. It should be in every hospital library. Bacteriological problems such as toxonomy, metabolism, antigenic structure and toxins occupy half the book; the remainder is concerned with reactions of the host, immunity, therapeutics and clinical problems. In its scope and balance the book as a whole is admirable; but, in the bacteriological section and in the chapters on antiseptics and antibiotics, there has been too little selection and the author has been submerged by his reference file. Perhaps the most valuable chapter is that on " Virulence and Disease "—a difficult subject but one to which Professor Elek has made his own useful contribution. There are two minor flaws to which the attention of orthopaedic surgeons might be drawn. On page 352 it is stated that the measurement of staphylococcal antitoxin is of negligible diagnostic value except possibly in bone and joint disease, and that even in this condition the greatest clinical information that can be derived is to indicate that a bone lesion found radiologically in a patient with a high antitoxin titre is more likely to be staphylococcal than tuberculous. This may be true if reliance is placed on a single titration, but a series of tests that show a rising titre of antitoxin is surely pathognomic. Surgeons should encourage their housemen to read the last chapter which deals mainly with hospital infection, but they should note that the dressing technique described was evolved in wartime and can be improved and simplified in civilian practice today.—Charles H. LACK.

POLIOMYELITIS. Papers and Discussions Presented at the Fourth International Poliomyelitis Conference. Compiled and edited for the International Poliomyelitis Congress. $10\frac{1}{4} \times 8$ in. Pp. xviii + 684, with 422 figures and 185 tables. Index. 1959. Philadelphia and Montreal: J. B. Lippincott Company. London: Pitman Medical Publishing Co. Ltd. Price 60s.

The report of the International Poliomyelitis Conference at Geneva in 1957 is as sumptuously produced as the three previous volumes, but is larger than the last by over a hundred pages. The orthopaedic surgeon whose only interest lies in the technique of his craft, and whose horizon suffers so severe a limitation, will find only forty-five pages of these transactions to hold his attention. Dr R. Bennett discussed the treatment of early paralytic scoliosis with adjustable corsets and exercises; Dr C. Ottolenghi expounded the surgical methods of improving scoliosis by fusion during growth,

with results admitted to be not entirely satisfactory; Mr R. Roaf insisted that rotation deformities of the spine must be corrected before fusion, and introduced his method of lateral vertebral epiphysiodesis for the growing child and resection of ribs and transverse processes for cosmetic improvement in the older patient; Dr V. Nickel convincingly summarised the combined use of reconstructive surgery and mechanical apparatus for the severely paralysed upper limb.

The highlight of this volume is like that of the report of the Third International Conference, and centres on virology and immunology. On the first day the conference plunged immediately into the battlefield of vaccination, and the debate between the supporters of the use of inactivated viruses and those advising the use of modified active viruses was of the greatest interest to hear. It is of equal interest to read, especially in the light of happenings since the debate occurred. At the time of the conference the advocates of the inactivated viruses were sanguine about the results of the programme of vaccination being conducted in the various countries, although Dr J. E. Salk uttered the warning note that a killed virus vaccine cannot be expected to have as great an effect on resistance to infection as it has on resistance to paralysis. More recent epidemics in Detroit and Israel have shown that the protection afforded by these vaccines is totally inadequate against the Type I virus. Dr H. Koprowski and Dr A. B. Sabin both spoke very ably on the feeding of attenuated viruses. Although they had no doubt that this is the method of choice when it can be brought to a pitch of absolute safety, Dr Sabin stated that, in view of the reduction of the incidence of paralytic poliomyelitis achieved by the killed virus vaccine, it is natural to incline to its use in countries in which its mass application is feasible. But, if the immunity so conferred should prove to be short, then supplementation by feeding with attenuated vaccine ought to be considered in order to induce resistance of the intestinal tract to re-infection. The wisdom of this suggestion is already becoming apparent from the statistics which are becoming available from all over the world since the conference.

The next day of the conference was taken up with the consideration of enteric viruses, with review of the developments in tissue culture methods in virology and of the outbreaks of aseptic meningitis produced by the many Echo and the Coxsackie viruses which so closely simulate those of poliomyelitis. The next two days were entirely concerned with studies on mammalian cells and the general considerations of viruses. The remaining sessions dealt with basic problems of respiratory distress, swallowing and glossopharyngeal breathing. The circulatory disturbances and the home management of respiratory cripples were also debated.

In the summary on care and rehabilitation is mentioned the work of Sherrington on the concept of proprioceptors now fifty years old. Surely the next conference in 1960 ought to devote a day to the fullest consideration of the many developments in neurophysiology which have occurred since Sherrington's day. The advances in this science have been very great, and the work of such men as Granit, Renshaw, Eccles and Wohlfarht ought to be assessed and applied to the study of poliomyelitis. This is some of the science too important to be left to the scientists—to repeat a remark made by the President of the Congress about another matter.

Anyone genuinely interested in poliomyelitis will want to possess this volume, which makes available so much information on the expanding study of the disease. The clinicians may well have a sad reflection that the amount of space required for their branch is steadily diminishing, and there is a dearth of notable advances in any way comparable with those in the scientific fields. However, they also serve who only seem to stand and wait until the disease be abolished.—John M. P. CLARK.

DEFICIENCY DISEASE. Functional and Structural Changes in Mammalia which Result from Exogenous or Endogenous Lack of One or More Essential Nutrients. By Richard H. FOLLIS, Jun., M.D. $10\frac{1}{4} \times 8$ in. Pp. xiii+577, with 182 figures and 20 tables. Index. 1958. Springfield, Illinois: Charles C. Thomas, Publisher. Oxford: Blackwell Scientific Publications. Toronto: The Ryerson Press. Price £5, 12s. 6d.

This book comprises a very complete exposition, by a recognised expert, of the known clinical and experimental deficiency diseases. It includes not only classical calorie, protein and vitamin deficiencies, but also considers the ordinary minerals and trace metals, the essential amino acids and some of the deficiencies secondary to other clinical conditions, such as steatorrhoea and pernicious anaemia. The emphasis throughout is on pathology, and the book is profusely illustrated with macroscopic and microscopic reproductions. Other books should be consulted for the fuller exposition of the purely clinical aspects, but this text is likely to become a standard one of its particular kind. It is very readable and should be of great value to medical student and postgraduate alike.—C. E. DENT.

HANDBUCH DER ORTHOPÄDIE. Herausgegeben von Prof. Dr G. HOHMANN, emer. Direktor der Orthopädischen Universitäts-Poliklinik und Orthopädischen Klinik München; Prof. Dr M. HACKENBROCH, Direktor der Orthopädischen Universitätsklinik Köln; und Prof. Dr K. LINDEMANN, Direktor der Orthopädischen Universitätsklinik Heidelberg-Schlierbach. In vier banden. Band II Spezielle Orthopädie Rumpf (Wirbelsäule und Becken). $10\frac{1}{2} \times 8$ in. Pp. xx+1,136, with 846 figures. 1958. Stuttgart: Georg Thieme Verlag. Price DM 174.

The second volume of this series, whose first volume we reviewed in 1958, has now appeared. Like its predecessor, Volume II is of over 1,100 pages and includes as many as 846 illustrations, the great majority of high quality. Under the names of Professor E. Güntz and Dr G. Exner, there are three sections on the development of the spine, its anatomy and function. Professor G. Hauberg describes kyphosis and lordosis. An extensive study of scoliosis of over 150 pages, mainly by Professor K. Lindemann and Dr H. Mau with the collaboration of Professors S. Weil and M. R. Francillon, constitutes a complete monograph in itself. As is to be expected, it brings forward many of the most important German contributions on this subject, without forgetting the main works from other countries. Particular attention is paid to some of the men who, like Schede, have influenced in one way or another present views on this problem. Much of the rest of the copious volume is also dedicated to the pathology of the spine and to its neurological complications. At the end of the volume the pathology of the scapulo-thoracic girdle and of the pelvis is described.

This second volume follows the pattern of the first for its quality of presentation, and I can only repeat what I wrote in my review of the first volume, namely that this book must take its proper place in the bookshelves of orthopaedic surgeons.—J. TRUETA.

MALIGNANT TUMOURS OF THE SPINE AND THE SPINAL EXTRADURAL SPACE. A Study Based on 250 Histologically Verified Cases. By Tapio TÖRMÄ. $9\frac{1}{2} \times 7$ in. Pp. 176, with many tables. 1957. Stockholm: Acta Chirurgica Scandinavica, Supplement 225. Price Sw. kr. 15.

This monograph is a study of 250 histologically verified malignant tumours of the spine and spinal extradural space from five Scandinavian neurosurgical departments. It contains a detailed analysis of the pathology of these tumours, their clinical features, diagnosis and treatment, and a comprehensive review of the papers on this subject. This painstaking study adds little to current knowledge of these tumours, but there is an excellent bibliography for those interested in the subject.—Roland BARNES.

PRIMARY TUMORS OF THE PELVIC BONES. A Roentgen Diagnostic Study of Eighty-three Cases. By Carl Gustav HELANDER and Åke LINDBOM. 10×7 in. Pp. 62, with 48 figures. 1957. Stockholm: Acta Radiologica, Supplement 152. Price Sw. kr. 25.

This excellent monograph reports an investigation into the radiological appearances in eighty-three cases of pelvic tumour collected at Karolinska Sjukhuset in Stockholm. Illustrations are profuse and excellent, and the text is succinct.

The various types of tumour encountered in the pelvis are described, and their incidence is related to that observed elsewhere in the skeleton. The main groups are accompanied by pelvic charts indicating the approximate sites of the individual tumours. Chondromatous tumours represented the largest group, with twenty-five cases, and are considered first; the section includes a valuable correlation of the radiological and histological findings in the three sub-groups of benign, locally malignant and highly malignant tumours. Other sections are concerned with fifteen giant-cell tumours, fourteen chordomas and eleven cases of Ewing's sarcoma. Reference is made to smaller series of osteogenic sarcomata and fibrosarcomata. Some purely benign lesions are also described, and a section on differential diagnosis is included.

Satisfactory records enabled the authors to give the periods of survival in most cases. The presenting symptoms, usually pain, are mentioned.

Attention is drawn to the interesting conclusion that the radiological appearance of tumours of different histological origin may present considerable similarity because of the anatomical configuration of the portion of the pelvis affected. Tumours growing slowly in the ischium, for example, have an appearance characteristic of that localisation, regardless of their histological type. Characteristics related to the age of onset and the mode and rate of tumour growth are also considered. The authors conclude that in most primary tumours of the pelvic bones biopsy is necessary to establish the nature of the neoplasm, and indicate that, whereas radiology may be diagnostic in perhaps a third of cases, in another third it will be impossible to make a more exact diagnosis than " tumour."

This small work should be invaluable for consultation and reference in cases of difficult radiological appearance of pelvic tumours.—R. O. MURRAY.

SPONDYLOLISTHESIS. A Study of 53 Cases Treated by Spine Fusion and 32 Cases Treated by Laminectomy. By L. E. LAURENT. Acta Orthopaedica Scandinavica. Supplement XXXV. From the Orthopaedic Hospital of the Invalid Foundation, Helsingfors, Head: Docent Anders Langenskiöld, M.D. $9\frac{3}{4} \times 6\frac{1}{4}$ in. Pp. 45, with 12 figures and 15 tables. 1958. Copenhagen: Ejnar Munksgaard Limited. Price Da. kr. 15.

This excellent little monograph from Finland does not pretend to be exhaustive but does provide a valuable review of the neurological changes and the surgical treatment. It is extraordinary that such a small subject should have attracted so much interest during the past forty years. Probably this is because of the etiological obscurity, the severe deformity which may result, and the surgical problems raised by attempts to reduce the deformity or to provide stability for an obviously weak section of the spine. During these years we have learnt that the initial lesion occurs during early childhood, that severe displacements may follow during adolescence, and that reduction more or less complete can sometimes be achieved; but it is extremely difficult, if not impossible, to retain this, nor does posterior bone grafting in adolescence provide any assurance against later further displacement. The writer of this paper reports upon seventy-seven of the patients who were treated surgically. Of these seventy-seven, forty-four were subjected to posterior spinal fusion, seven to anterior fusion and twenty-six to laminectomy without fusion. The results of fusion were better than those of laminectomy without fusion. The extent of slipping did not influence the results. The indication for operative treatment is persistent pain that is not relieved by conservative treatment. In adolescents where olisthesis appears likely to lead to total displacement fusion should also be performed.—Norman CAPENER.

INJURIES AND SURGICAL DISEASES OF THE ISCHIUM. By Henry MILCH, M.D., Attending Orthopaedic Surgeon, Hospital for Joint Diseases, New York. $10\frac{1}{4} \times 7\frac{1}{4}$ in. Pp. x+163, with 106 figures. 1958. Index. New York: A Hoeber-Harper Book. London: Pitman Medical Publishing Co. Ltd. Price £4, 4s.

Any book solely devoted to a small specialised subject must inevitably stress points which can have very little practical value. This monograph is no exception. It gives an exhaustive account of the anatomy, injuries and diseases of the ischium. For example, the fact that " a fissure fracture may sometimes be overlooked " can hardly be of even academic interest. Similarly, the twelve pages devoted to the rather rare condition of ischial apophysiolysis prove to be tedious reading. There are over a hundred illustrations; but unfortunately many of the reproductions of radiographs are of very poor quality and this makes it very difficult to appreciate the points being shown.

Much of the work is a review of the literature and there is a full bibliography at the end of each chapter. This may prove of value to anyone who is engaged in research on the same subject. The best part of the book comes at the end, where there is an excellent chapter on the surgery of the ischium. The illustrations of the operation for excision of the ischium are particularly good. This part should be read by anyone who is contemplating excising this bone for tumour or other disease.—J. N. WILSON.

FRACTURE OF THE OS CALCIS AND ITS TREATMENT. II. A Contribution to the discussion on the treatment of calcaneus fracture based on an analysis of a ten-year material treated by closed reduction and traction, from Sentralsykehuset i Trondheim. By Arne ARNESEN. $9\frac{1}{2} \times 7$ in. Pp. 70, with 60 radiographs, 54 figures, 2 photographs and 21 tables. 1958. Stockholm: Acta Chirurgica Scandinavica, Supplement 234. Price Sw. kr. 10.

This monograph on the treatment of fractures of the calcaneum by Arnesen of Trondheim deals mainly with a detailed study of fifty-eight patients with this troublesome injury. The usual Norwegian thoroughness and attention to detail are pleasant features, and, although the English translation is somewhat quaint, the meaning is clear enough. The author is obviously honest in assessing his results and does not claim to have mastered the tongue-type or the severe stamp-type of deformity. He does claim, and with good reason, that divergent traction through the metatarsals and through the tuberosity of the calcaneum, plus manipulation, can wholly restore the tuber-joint angle, and lead to good results in 90 per cent of the depression type of fractures. The author described this method of treatment in 1939; in the present work he describes several changes in technique which he thinks have been responsible for an improvement in results. Traction is maintained for six weeks, because the ordinary calcaneal fracture is stable at the end of this time; plaster fixation has been given up; active exercises are considered essential, and are started as soon as traction has been applied. This is a stimulating and valuable contribution towards the solution of this difficult problem—the adequate treatment of fracture of the calcaneum.—L. W. PLEWES.

ROENTGEN MANIFESTATIONS OF ADULT RHEUMATOID ARTHRITIS with Special Regard to the Early Changes. By Pekka SOILA. Translated by Alan R. Beesley, B.A. $9\frac{1}{4}\times6\frac{1}{4}$ in. Pp. 144, with 63 figures and 10 tables. Turku (Finland) 1958. Stockholm: Acta Rheumatologica Scandinavica, Supplement 1. Price Sw. kr. 35.

The author of this work has made an extensive and scholarly investigation into the value of radiology in the diagnosis of rheumatoid arthritis. In a series of 407 males and 625 females suffering from the earlier stages of the disease radiographs of the hands, feet, ankles and knees were made, as far as possible without variation of technique. This material was employed to assess the time of appearance and rate of progress of radiological signs. This was then subjected to exhaustive statistical analysis in which the stages of the disease, the sex incidence, the age of onset and the sites affected were considered. Despite considerable variations the author concluded that radiology is of the first importance in establishing the diagnosis and in differentiating the condition from other types of arthritis. An extensive review of the literature with a large bibliography is included. One cannot help admiring the minute detail with which this work has been prepared. Most of the conclusions inevitably tend to confirm previous observations in a condition that has been the subject of so much research. Nevertheless, the author has several new and interesting points to describe, particularly in the earliest phases of the disease. The reproduction of the numerous radiographs does not do justice to the text. This work is to be recommended to specialists in rheumatology, both clinical and radiological.—R. O. MURRAY.

ORTHOPAEDIC SURGERY. By Sir Walter MERCER, M.B., Ch.B. (Edin.). M.Ch.Orth. (Liv.) (Hon.), F.R.C.S. (Edin.), F.A.C.S. (Hon.), F.R.C.S. (Eng.) (Hon.), F.C.S.So.Af. (Hon.), F.R.S. (Edin.), Professor Emeritus, Orthopaedic Surgery, University of Edinburgh. Fifth edition. $9\frac{1}{4}\times7\frac{1}{2}$ in. Pp. xi+1,075, with 422 figures. Index. 1959. London: Edward Arnold (Publishers) Ltd. Price 90s.

This is a friendly review, but there is more to it than that; for I have read this fifth edition with the same interest and the same appraisal as I did the first many years ago. New knowledge has been incorporated, and I particularly like the articles on congenital dislocation of the hip and on infantile paralysis by George Mitchell and that on cerebral palsy by George Pollock. There are paragraphs that I would myself have relegated to a historical footnote such as those on Carrel-Dakin irrigation, the Winnett-Orr treatment for chronic osteomyelitis and subperiosteal resection for acute osteomyelitis; for they, like the Gibson Girl, though once admired are now outmoded. But in making this criticism I am reminded of the editor's reply to the criticism that *Punch* was not so good now as it was . . . " it never has been." It is no use criticising as old fashioned something that goes on for ever, and it looks as though Mercer, now in its twenty-seventh year, will continue to do just that.—George PERKINS.

ALLGEMEINE UND SPEZIELLE CHIRURGISCHE OPERATIONSLEHRE. By Gerd HEGEMANN, O.Ö. Professor der Chirurgie, Direktor der Chirurgischen Klinik der Universität Erlangen. Volumes I and II. 10×7 in. Vol. I—Pp. xix+420, with 378 figures, many in colour, and 12 tables. Vol. II—Pp. xiii+747, with 256 figures, many in colour, and 108 tables. Index. 1958. Berlin, Göttingen, Heidelberg: Springer-Verlag. Price DM 496.

This book is an attempt to reduce the harm which over-specialisation is causing to the progress of the surgical art. It was originated by Kirschner in the late 'twenties and consisted of thirteen volumes, but of this new edition by Professor G. Hegemann only the first two volumes are as yet available for review. The first volume gives detailed instruction in general surgical techniques including sterilisation of instruments and aseptic theatre technique, posturing of patients on the operation table, incisions, sutures and drainage. A section on plastic, vascular, nerve, bone and tendon surgery completes the first volume. The second volume describes, with profusion of detail, local and general anaesthesia, treatment of wounds, shock, phlebothrombosis and several other subjects of general surgical interest.

As in all books written on a large number of subjects, the value of each section depends on the particular standing of the writer, and it is impossible for a reviewer to discuss the pertinence of details, even if he occasionally does not agree with the recommendations made in the book. Such an instance is the description of accidental wound treatment, well illustrated by drawings (drawings which by the way have a striking similarity to the series of illustrations that the reviewer published in a book in 1943). Local analgesia by infiltration is still recommended in excising the wound of a compound fracture, a

total departure from modern practice, at least in all hospitals where general anaesthesia by inhalation has reached the required standards of efficiency and safety. Blood transfusion, chemotherapy, " crush syndrome " and other complications of injury and operation are given a deserved place.

These two volumes are elegantly presented and beautifully illustrated by over six hundred plates, in black and white and colour, over their 1,200 pages. They are valuable works of reference and may attract an orthopaedic surgeon who likes to be informed of the recent trends in general surgery prevailing in Germany.—J. TRUETA.

WESEN UND BEDEUTUNG DER ENCHONDRALEN DYSOSTOSEN. By Dr Med. Hans MAU, Heidelberg. Mit Einem Geleitwort von Professor Dr K. LINDEMANN, Heidelberg. 9½×7 in. Pp. xi+219, with 83 figures. 1958. Stuttgart: Georg Thieme Verlag. Price DM 27.

The author of the present monograph is the son of the late Professor C. Mau, Director of the Institute of Orthopaedics of Hamburg, and is a student of Professor K. Lindemann, Director of the Institute of Orthopaedics of Heidelberg, who wrote the preface to the book.

The importance of this work lies mainly in the aim to amplify the meaning of the word " osteochondrodystrophy " (Léri's disease, Pfaundler-Hurler's disease, Morquio's disease) as it is accepted at present by most observers. The author groups together, under the same heading, all the various disturbances in endochondral ossification, generalised or localised, that derive from congenital disorders; but he emphasises that a distinction should be made between metaphysial and epiphysial errors of ossification, although they belong to the same category. Each syndrome may give full clinical manifestations or only a few and incomplete signs, and sometimes mixed forms can be found which present a very difficult diagnosis.

The author is mainly interested in the " formes frustes," or atypical forms, and he believes that they are partly accounted for by a peculiar congenital predisposition in the ossification centres, which are unduly subject to changes induced by weight bearing and by imbalance in blood circulation. If one accepts this assumption, aseptic bone necrosis (osteochondritis dissecans) and several forms of early and quite disabling arthritis should be interpreted as consequences of such a chondrodystrophic diathesis. Actually the congenital anomaly under discussion, or hereditary inborn error of skeletal maturation, is characterised by shortness in stature, peculiar endocrine abnormalities, irregular appearance and fragmentation of the ossification centres, and " pseudoepiphyses." The symptoms are essentially an exaggeration of those that are found in the well known forms of osteochondrodystrophy along with extra-skeletal defects—nervous, ocular, visceral and haematological dyscrasias.

In the second part of the monograph particular attention is given to the different kinds of osteochondrodystrophies, in order of localisation. Extensive consideration is given to the changes in the vertebral column, pelvic bones and hips. The study of such alterations may be of great help in elucidating the pathogenesis of primary scoliosis and of high grade congenital dislocations of the hip resistant to all kinds of therapy.

Inasmuch as these new concepts may appear to conflict with the fundamentals of classic orthopaedics, the experienced clinician must admit that congenital skeletal deformities are very often associated with profound changes in the normal ossification processes, particularly of the hip joint and vertebrae.

Brief indications about differential diagnosis, prophylaxis, therapy and social medicine conclude the interesting monograph.—C. CASUCCIO.

INDICATIONS ET RÉSULTATS DE L'OSTÉOTOMIE DE VARISATION DE LA HANCHE. (Opération de F. Pauwels.) By André LAPRAS, Ancien Interne des Hôpitaux de Lyon. Travail de la Clinique de Chirurgie Orthopédique et Infantile de la Faculté de Médecine de Lyon Professeur M. Guilleminet. 9½×6¼ in. Pp. 116, with 26 figures and 3 tables. 1958. Lyon: Imprimerie Bosc Frères. Complimentary copies available from author, Hôpital Edouard-Herriot, Lyon.

This is a review of sixty-one patients treated by various forms of femoral osteotomy between October 1950 and October 1958 in the Orthopaedic Service of the University of Lyon. The rationale and methods follow closely those of Professor F. Pauwels of Aachen. Dr Lapras reviews briefly some of Professor Pauwel's research into the mechanisms of the hip joint, both normal and abnormal, and the effects of cuneiform osteotomy in cases of coxa valga and hip subluxation. The details are given of preliminary radiological examination, operation and subsequent care. In the sixty-two operations in the sixty-one patients there were no deaths and no immediate complications except three cases of

vein thrombosis, all of which responded to anticoagulant therapy. In six patients anteversion was corrected at the same time, and in one of these a second operation was required for malposition. After this incident a special plate was devised and used in all later cases. Pauwels specifically avoided correction of rotation, and in his hands a 10-centimetre intramedullary nail gave a satisfactory fixation. This series is not presented as a long term study; but immediate results in abolition of pain have so impressed the author that he advocates varus osteotomy for all cases of painful osteoarthritis with coxa valga or subluxation, provided that the head of the femur can be accommodated within the acetabulum. He also advises varus cuneiform osteotomy, as a prophylactic measure, for adolescents and young adults presenting coxa valga and subluxation without pain. This monograph gives in simple language a good idea of Pauwel's theories and practice, and one must hope that the author's optimistic outlook will be justified by longer observation of these patients.—Charles MANNING.

SKIN ARTHROPLASTY IN THE LIGHT OF ANIMAL EXPERIMENTS WITH SPECIAL REFERENCE TO FUNCTIONAL METAPLASIA OF CONNECTIVE TISSUE. By Kauko O. KETTUNEN. Acta Orthopaedica Scandinavica, Supplement 29. 9¼×6½ in. Pp. 75, with 41 figures (some in colour) and 3 tables. 1958. Copenhagen: Ejnar Munksgaard Limited. Price Da. kr. 25.

This experimental study has been inspired by the work of Dr E. Kallio on skin arthroplasty of the hip. It gives convincing evidence that metaplastic cartilage is formed at the site of interposition of the skin. Experiments were carried out on the hips of thirty-seven cats. In thirty, a skin arthroplasty was performed after the removal of cartilage from the acetabulum. In seven a control operation was performed without interposition of skin. In the control series it was found that no fibrous tissue protection formed over the bare bone of the acetabulum, and that the joint space gradually disappeared. In the weight-bearing areas of the joint it seemed that granulation tissue had been destroyed. Where skin interposition had been used remnants of the graft could be seen for two months. During this time the skin was gradually replaced by granulation tissue which became organised into fibrous tissue. After two months the latter showed signs of changing into cartilage. This metaplasia was found to be greatest at the weight-bearing sites, and did not occur if there was no loading by weight bearing, for instance if dislocation occurred.

These findings confirm the clinical observations made by many workers in the field of Vitallium Mould Arthroplasty and support the findings of a recent comparative study of the latter operation with skin arthroplasty (Kallio 1958). It would appear, therefore, that this operation can do everything expected from its Vitallium counterpart, and has the added advantage that when the " mould " has done its job it is removed by the body. It is possible that this procedure may have its most useful application in hip arthroplasty in the young, such as in the treatment of the missed congenital dislocation. It will be interesting and instructive to hear more about this operation when the long term results are available.—J. N. WILSON.

REFERENCE

KALLIO, E. (1958): Skin Arthroplasty of the Hip Joint and Corresponding Alloplastic Methods in the Light of a Clinical Study. Acta Orthopaedica Scandinavica, Supplementum No. xxx. (Reviewed in this journal, 1958, **40-B**, 851.)

STUDIES ON WEIGHT-DISTRIBUTION UPON THE LOWER EXTREMITIES IN INDIVIDUALS WORKING IN A STANDING POSITION. Assessing the Results of the Measurements of Load-pressure Differences Against the Background of Handedness and Some Clinical Observations. By Axel MARSK. Acta Orthopaedica Scandinavica, Supplement 31. 9×6¼ in. Pp. 64, with 27 figures and 13 tables. 1958. Copenhagen: Ejnar Munksgaard Limited. Price Da. kr. 20.

This is an exhaustive work in biomechanics on the distribution of body weight between the right and left legs in relation to whether the patient is right- or left-handed. During the course of their employment, workmen carried a radio transmitter in a rucksack on their shoulders connected with pressure-sensitive elements in sandals attached over their boots. Signals from this apparatus were recorded and interpreted by a receiving station. It was found that right-handed persons very consistently weighted the left foot more than the right. On the other hand, left-handed persons did not weight the right foot with the same dominance, though this contralateral foot did take most of the weight.—John CHARNLEY.

A CONCISE TEXTBOOK OF ANATOMY AND PHYSIOLOGY APPLIED FOR ORTHOPAEDIC NURSES. By Joyce W. Rowe, S.R.N., S.C.M., O.N.C., Sister Tutor, Mansfield Orthopaedic Hospital; and Victor H Wheble, M.A., B.M., F.R.C.S. Ed., Senior Orthopaedic Registrar, Mansfield Orthopaedic Hospital, Nottingham. $8\frac{1}{2} \times 5\frac{1}{2}$ in. Pp. viii+688, with 504 figures. Index. 1959. Edinburgh and London: E. & S. Livingstone Ltd. Price 35s.

This book is written primarily for nurses taking the Orthopaedic Nursing Certificate of the Joint Examination Board of the British Orthopaedic Association and of the Central Council for the Care of Cripples. While there is perhaps overmuch detailed anatomy for the student of general nursing, the authors point out that it may be a useful book for those taking courses in the ancillary medical subjects of occupational therapy, physiotherapy and radiography. With these sentiments I heartily agree and would add the hope that it will be read by medical students when revising their anatomy and physiology. The fact that both subjects are combined in one volume is a unique asset, and the authors are to be congratulated. There is more than this, however, for at the end of each section is a paragraph on applied anatomy. For example, the anatomy and physiology of posture is discussed, to be followed by some practical advice as to how a nurse should lift a patient. Or again, the anatomy of the brachial plexus is followed by a simple description of nerve lesions in the arm. One wonders whether this type of book may not set a pattern for the future reading of the pre-clinical medical student, who is already overburdened with detail in the basic sciences. The chapter headings are biblical quotations, chosen to stimulate interest in the subject matter and indeed to emphasise, as the authors stress, that there is a spiritual as well as a physical aspect of the human being. Other notable features are a selection of examination questions at the end of each chapter, a section on regional and surface anatomy, and a useful glossary of medical terms. The book is profusely illustrated with black-and-white drawings and diagrams. These are excellent for the most part and leave a distinct flavour of *Gray's Anatomy*; a few, concerned with the anatomy of the posterior abdominal wall and limbs, I found distinctly heavy going. It is a pity that the paper changes from matt to glossy towards the end of the book. Radiographs are thus excellently reproduced but the print is rather less pleasant to read. Nevertheless, the general clarity, style and format are excellent as we would expect from the House of Livingstone.—H. L.-C. Wood.

RE-EDUCATION OF THE INJURED SHOULDER. By R. Barrie Brookes, F.C.S.P., Rehabilitation Officer, Birmingham Accident Hospital. $9 \times 5\frac{3}{4}$ in. Pp. viii+114, with 59 figures. Index. 1959. Edinburgh and London: E. & S. Livingstone Ltd. Price 12s. 6d.

This monograph was presented as a thesis which deservedly gained the author an award of the Fellowship of the Chartered Society of Physiotherapists. The greater part consists of an account of the anatomy and pathology of the shoulder joint which, as he points out himself, is necessarily based on second-hand information; but he has chosen his authorities wisely and it is a good account. This basic knowledge has led Mr Brookes to develop a rational and practical routine of treatment which is explained in some detail. The book should be of considerable value to physiotherapists to whom it is warmly recommended.—Philip Wiles.